SPACE ATLAS

OF LEBANON

Space Images
Physical Characteristics
Landscape & Cultural Heritage
Natural Resources
Urbanization
Risk studies

SPATIAL ATLAS OF LEBANON

SPACE ATLAS
of Lebanon

National Council for Scientific Research

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This book contains information obtained from authentic and highly regarded sources. Reprinted material is quoted with permission, and sources are indicated. A large list of references is listed. Every possible attention has been taken to ensure that, to the best of our knowledge, the information contained in this atlas is accurate at the date of publication. However, we cannot guarantee that our work is entirely free of error and whilst we would be grateful to learn of any inaccuracies, we do not accept responsibility for loss or damage resulting from reliance on information contained within this publication.

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Foreword

The Space Atlas of Lebanon is the first atlas of its kind published by the Lebanese National Council for Scientific Research (CNRS-L) covering almost all aspects of Lebanon's natural resources: agriculture, water resources, soil, geology, and forest cover. It sheds light on the available natural resources of Lebanon as viewed from space, exposing almost all aspects of natural hazards that can affect the country in the future, and emphasizing on the factors threatening these resources, especially, the anthropogenic causes of environmental degradation. The range of such causes varies from issues pertaining to the overall economic and environmental conditions, to those affecting the limited resources and the ecology of the marine and terrestrial environments.

Remote Sensing was used, in combination with Geographic Information System techniques to determine the acute deterioration and depletion of the country's natural resources.

The information exposed in this Atlas aim to describe the real situation of Natural Resources of Lebanon in order to predict how the future is likely to be. Accordingly, risk mitigation can be achieved with a better assessment and analysis of remotely sensed satellite images.

We are grateful to all those who provided comments and remarks which helped shape the book in its final form.

Signature

Prof. Mouin Hamzé

Secretary General of
the Lebanese National Council
for Scientific Research

A Brief Introduction about the Lebanese National Council for Scientific Research (CNRS-L)

The National Council for Scientific Research in Lebanon (CNRS-L) was established in 1962 as a central science policy-making public institution under the authority of the Prime Minister and granted administrative and financial autonomy. The CNRS-L manages and runs the following research centres:

National Centre for Remote Sensing
The Remote Sensing Centre (NCRS) was established in 1995 and became fully operational in 1997. This came as the culmination of focused efforts to catch up with recent advances in remote sensing and GIS technology. The Centre has links and collaborative programmes with various regional and international organizations and institutions.
The Centre has proved to be an important facility for decision makers as it is supporting various activities that are essential to several ministries. The NCRS is responsible for acquisition and processing of satellite imagery, providing remote sensing data and continuously exploring the practical uses of remote sensing technology for multidisciplinary applications.
The NCRS has to its credit various studies dealing with watershed and forestry management, urban settlements, archaeology and environment, integrated coastal zone management, natural hazards, including an updated and new soil map of Lebanon. Furthermore, the centre is cooperating with several development projects and securing highly needed upgraded information and data necessary for environmental monitoring in various sectors; in addition to producing various thematic maps and training staff of various public agencies on requirements and applications of remote sensing and GIS.

2. National Centre for Marine Sciences
Established in 1977, the National Centre for Marine Sciences (NCMS) comprises of a multi-skilled group of scientists and researchers committed to carrying out research in marine sciences, particularly sources and factors of coastal pollution, and the conservation of and protection marine ecosystems and biodiversity. In addition, the CMS supports diverse coastal and marine studies tackling the development of sea resources.
In 2006, the Italian Government presented a valuable donation to the Centre; a scientific vessel, named CANA-CNRS, to support marine and geophysical research in Lebanon.

3. National Centre for Geophysical Research
The National Centre for Geophysical Research (NCGR) was established in 1975 by the Lebanese Government when the NCSR regained the control of Ksara Observatory. It is operated by a small number of experts from its headquarters in Bhanness and its branch stations in Houka, Fak'ha, Hasbaya and Ansar. The centre's main activities include studies on seismic activities and terrestrial magnetic field measurements, from its observatory in Qsaybeh. The centre is also responsible for monitoring earthquakes and seismic activity at the national level and studying the seismicity of Lebanon. The centre is the national reference for seismic activity measurements.

4. Lebanese Atomic Energy Commission
The Lebanese Atomic Energy Commission (LAEC) was established in the year 1995 through a support grant from the International Atomic Energy Commission Agency. The centre is located in Beirut, where approximately seventy researchers, experts, engineers and technicians work. The centre is engaged in broad based multidisciplinary research programmes focusing on the radioprotection infrastructure of all radioactivity sources in Lebanon and conducts surveys on possible radioactive pollution. The LAEC cooperates closely with the Ministry of Public Health and the General Directorate of Customs, particularly in controlling the impact of radioactive sources and equipment used as sources of ionizing radiation. The mandate of the LAEC has been extended to cover the monitoring of the radioactivity of imported commodities and related equipment, and to maintain a national record of all radioactive materials and equipment in Lebanon.

Major activities of the CNRS-L

• Scholarship Grant Program
The CNRS-L supports scientific research programmes and provides Ph.D. scholarships to Lebanese students specializing in various disciplines abroad. Over 450 graduates from this programme currently work in Lebanese universities. Likewise most of the senior staff members of the CNRS-L are past recipients of these fellowships.

• Research Grant Program
The CNRS-L established programmes designed to offer grants for specific projects carried out by individual researchers or university professors and for multidisciplinary projects focusing on a definite discipline.
The CNRS-L established programmes designed to offer grants for specific projects carried out by individual researchers or university professors and for multidisciplinary teams focusing on a definite discipline.

• International and Regional Cooperation
The CNRS-L provides a platform for scientific cooperation between researchers from Lebanon and others countries such as Syria and Italy. Currently it is involved in several programs, such as the Lebanese Syrian Cooperation programme, program Cedre, CNR (Italy) - CNRS (Lebanon) Agreement & Cooperative programme and the Framework Agreement between the CNRS (Lebanon) & Politecnico Di Milano (Italy).

• International Projects
The CNRS-L has several international projects such as: Establishing Monitoring and Sustainable Development of the Lebanese Sea (CANA), Improving National Assessment and Monitoring Capacities for Integrated Environmental and Coastal Ecosystem (INCAM) Management), Mediterranean Innovation and Research Coordination Action (MIRA), Establishing the EU-Mediterranean ICT Research Network (JOIN-MED), Regional Coordination on Improved Water Resources Management and Capacity Building Program, and Capacity Building in Water Project (CAPWATER).

LIST OF ACRONYMS AND ABBREVIATIONS

AD: Anno Domini
AUB: American University of Beirut
BC: Before Christ
CAPWATER: Capacity Building in Water
CANA: Establishing Monitoring and Sustainable Development of the Lebanese Sea
CDR: Council for Development and Reconstruction
CGR: Centre for Geophysical Research
CMS: Centre for Marine Sciences
LNCSR: Lebanese National Council for Scientific Research
DEM: Digital Elevation Model
DGUP: Directorate General for Urban Planning
FAO: Food and Agricultural Organization of the United Nations
GIS: Geographic Information System
IBA: Important Bird Area
INCAM: Improving National Assessment and Monitoring Capacities for Integrated Environmental and Coastal Ecosystem Management
Join-Med: Establishing the EU-Mediterranean ICT Research Network
LAEC: Lebanese Atomic Energy Commission
LBP: Lebanese Pound
IPC: Iraq Petroleum Company
IR: Infrared
MIRA: Mediterranean Innovation and Research Coordination Action
MoA: Ministry of Agriculture
MoE: Ministry of Environment
NCGR: National Centre for Geophysical Research
NCMS: National Centre for Marine Sciences
NCRS: National Center for Remote Sensing
NAP: National Action Plan
NR: Natural Reserves
NGO: Non-Governmental Organization
OWLs: Other Wooded Lands
RAMSAR: Convention on Wetlands of International Importance
RSC: Remote Sensing Centre
SOTER: Soil and terrain database
UNEP: United Nations Environment Programme
UNESCO: United Nations Educational, Scientific and Cultural Organization
USDA: United States Department of Agriculture
WRB: World Reference Base on Soil Resources

Symbols and Units

cm: centimetres
ha: hectares
km: Kilometre
km^2: Square Kilometre
$: United States Dollar
asl: above the sea level

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Introduction

This Space Atlas is the first Atlas for Lebanon based on satellite images covering the entire country. It is the product of multidisciplinary research and studies involving advanced Remote Sensing and Geographic Information System techniques. This survey was carried out in considerable details, covering 10284 km^2. In almost all the country, the existing natural resources as well as the main factors contributing to both their conservation and loss were identified. Accurate details obtained, proved necessary and advantageous in identifying the main threats for Lebanon resources likely to emerge in the coming years. The Space Atlas of Lebanon was developed by the Remote Sensing Centre of the CNRS-L, with the objective of presenting Lebanon as it is seen from space. The current work is designed to answer questions of those interested in understanding the evolution of technologies used in the analysis of geographic, physical, and social themes; to present information in environmental areas such as territorial development, natural and archaeological environments, pollution and seismology. This work is a continuity and complementarity of the preceding Lebanese Atlases. It puts forward an educational approach to Remote Sensing and demonstrates tangible techniques and applications in the fields of image processing and spatial assessment of satellite data. The Atlas development made use of collaboration between different CNRS-L departments, especially those related to remote sensing, in addition to the contribution from the General Directorate of Antiquities.
The Atlas is structured as follows:
The first section presents the spatial organization of the Lebanese territories including its conurbation and cities. It assesses the current situation and evolution of the urban spaces as well as the communication infrastructures
Sections 2, 3 and 4 describe the physical characteristics of land as well as the natural resources of Lebanon, mainly vegetation cover, soil, water, agriculture, natural and archaeological sites through Remote Sensing Spatial Analysis of Satellite Images.
Section 5 depicts the urbanization and economy in terms of airports, infrastructure and industrial sites.
Section 6 deals with different themes covering risk analysis of natural threats (e.g. earthquake, landslides, and soil erosion) and human induced pressures. Also portrayed are the priority challenges such as pollution, desertification and forest fires.
Remote sensing is a discipline that consists of studying objects and physical phenomena by acquiring information distantly. The main remote sensing technique is by far the study of terrestrial environments using different sensors on board of a range of satellites or airplanes. These sensors are sensitive to the electromagnetic radiation emitted or reflected from the terrestrial surface or its atmosphere. A science which started in the 19th century, remote sensing evolved during the two world wars, especially, through the contest and race to the exploitation of space. Fields of information are diverse and diverge in different domains such as those of meteorology and climatology, oceanography, cartography, and geography. However, the use of Remote Sensing in combination with (GIS) also strengthens the integration of new information leading to further assessments of natural as well as the impact of human beings on natural resources.

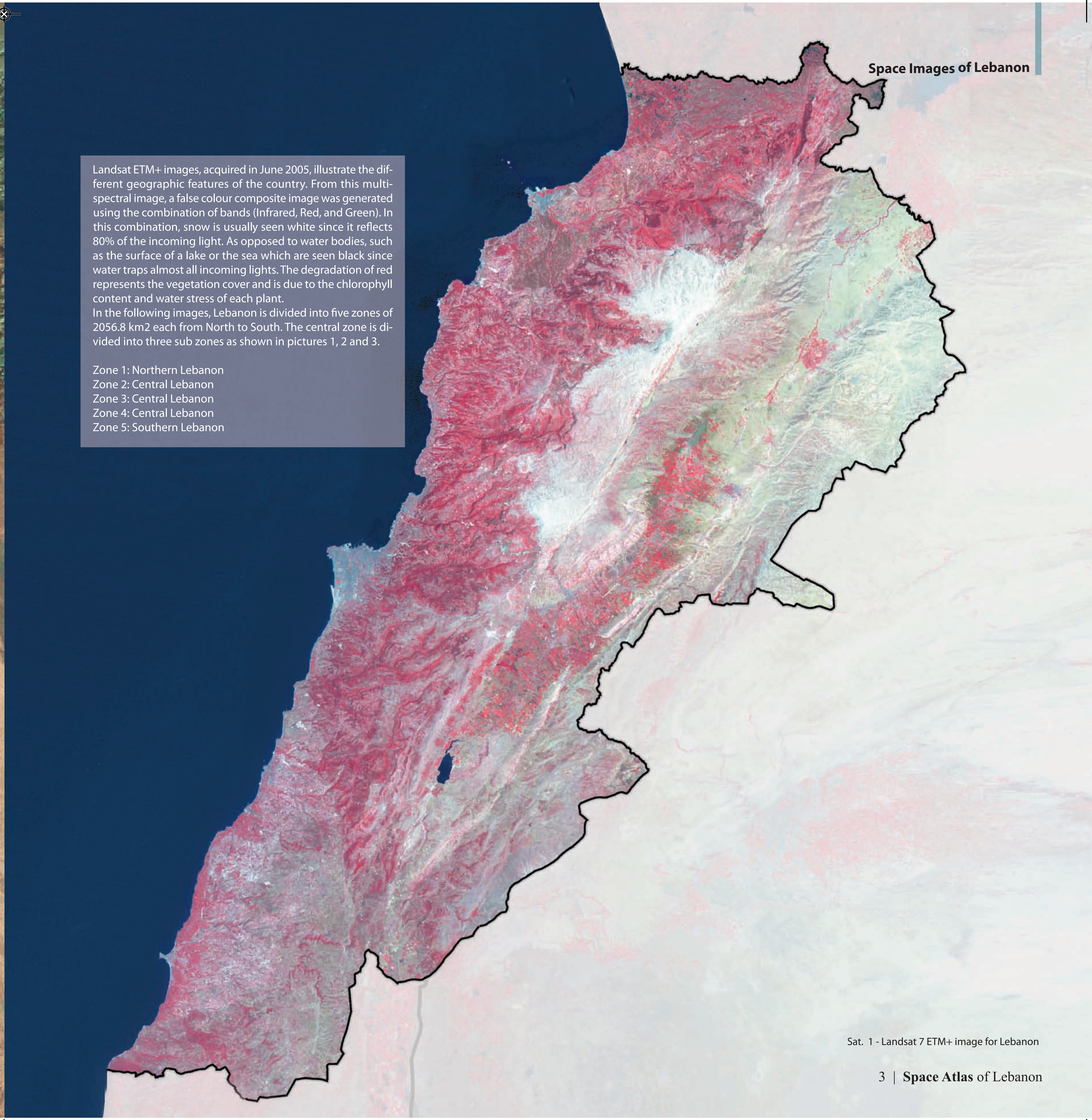
Section 1

Space **Images** Of Lebanon

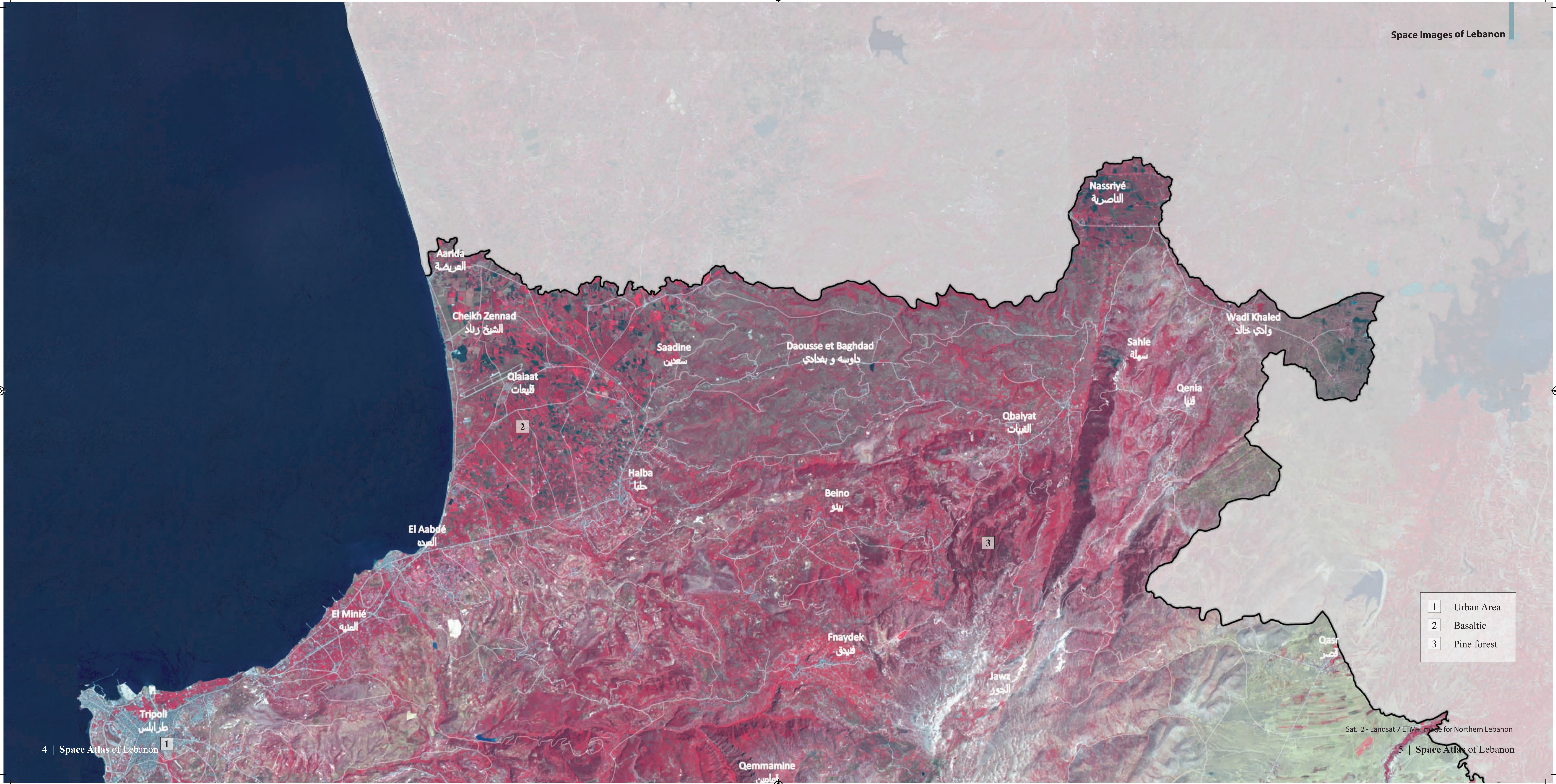
Lebanon is located on the Eastern shore of the Mediterranean Sea, at the meeting point of three continents, Europe, Africa and Asia. It has been the crossroad of many civilizations whose traces may still be seen today. It is bordered from the north and east by Syria and from the south by Palestine. The total area of the country is approximately 10,284 square kilometres (4,500 square miles). Lebanon is characterized by its moderate climate which is affected by the Mediterranean Sea from the West and the desert area in the East.

Landsat ETM+ images, acquired in June 2005, illustrate the different geographic features of the country. From this multispectral image, a false colour composite image was generated using the combination of bands (Infrared, Red, and Green). In this combination, snow is usually seen white since it reflects 80% of the incoming light. As opposed to water bodies, such as the surface of a lake or the sea which are seen black since water traps almost all incoming lights. The degradation of red represents the vegetation cover and is due to the chlorophyll content and water stress of each plant.
In the following images, Lebanon is divided into five zones of 2056.8 km2 each from North to South. The central zone is divided into three sub zones as shown in pictures 1, 2 and 3.

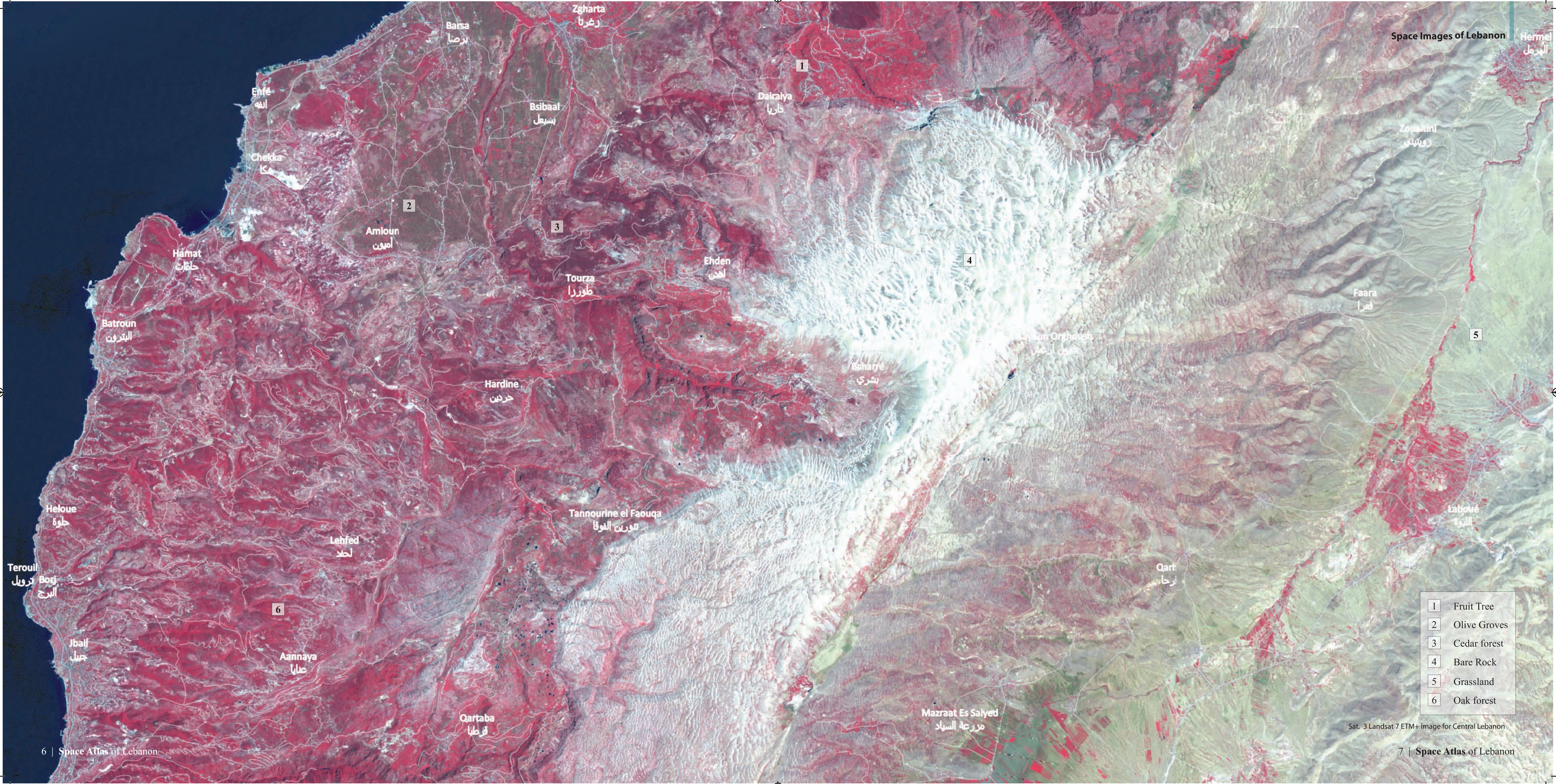
Zone 1: Northern Lebanon
Zone 2: Central Lebanon
Zone 3: Central Lebanon
Zone 4: Central Lebanon
Zone 5: Southern Lebanon



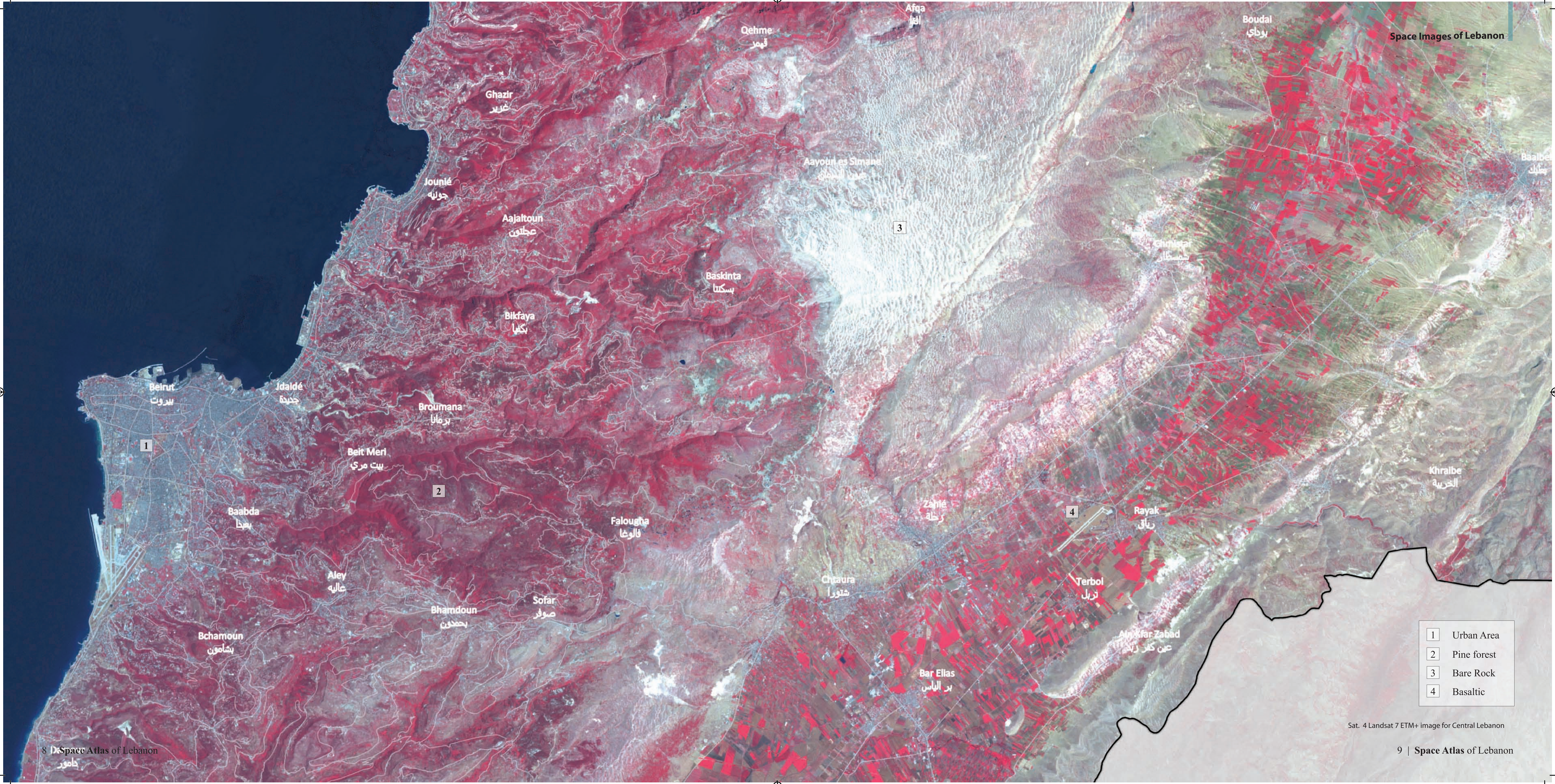
Sat. 1 - Landsat 7 ETM+ image for Lebanon



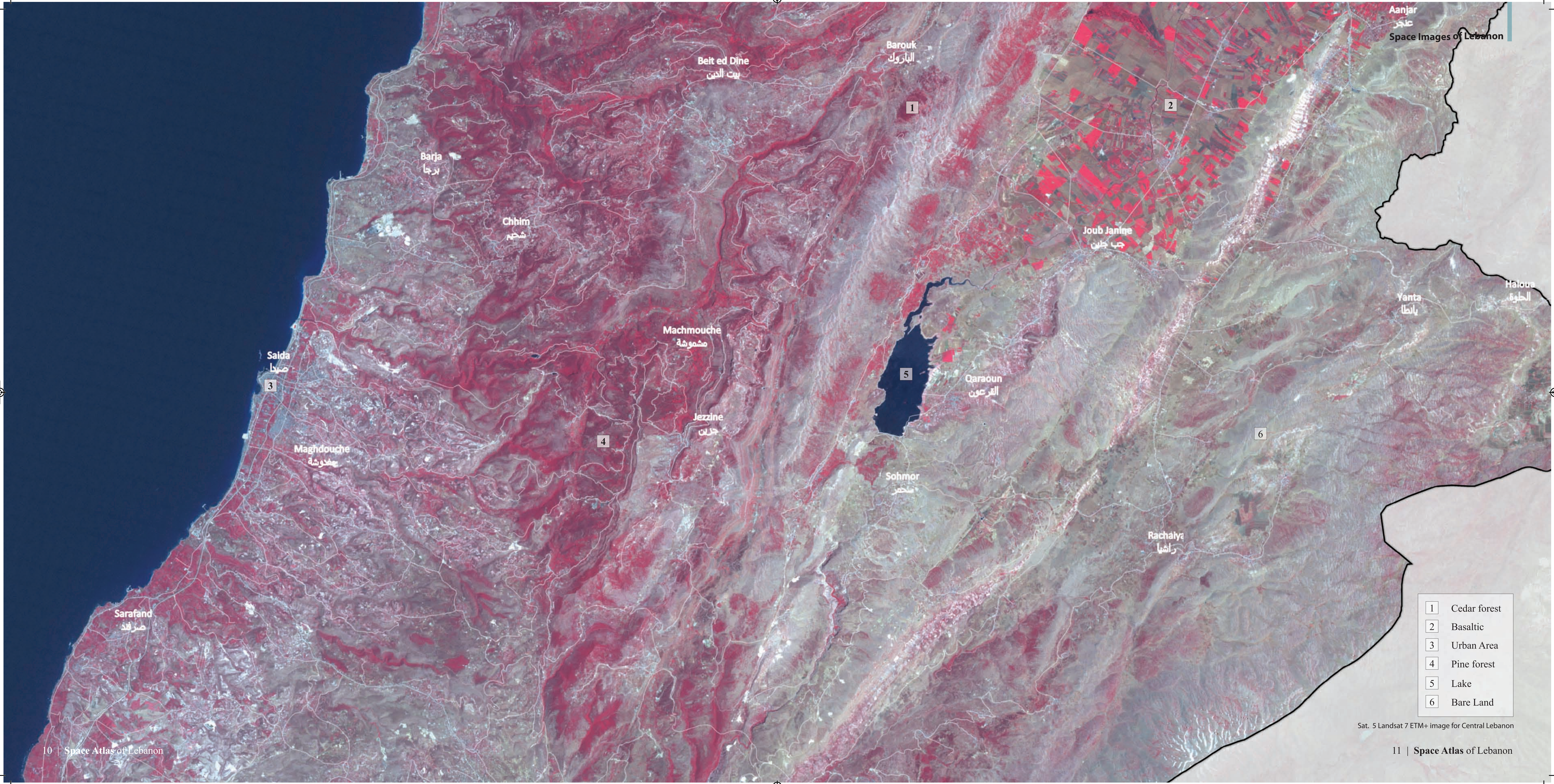
Sat. 2 - Landsat 7 ETM+ image for Northern Lebanon



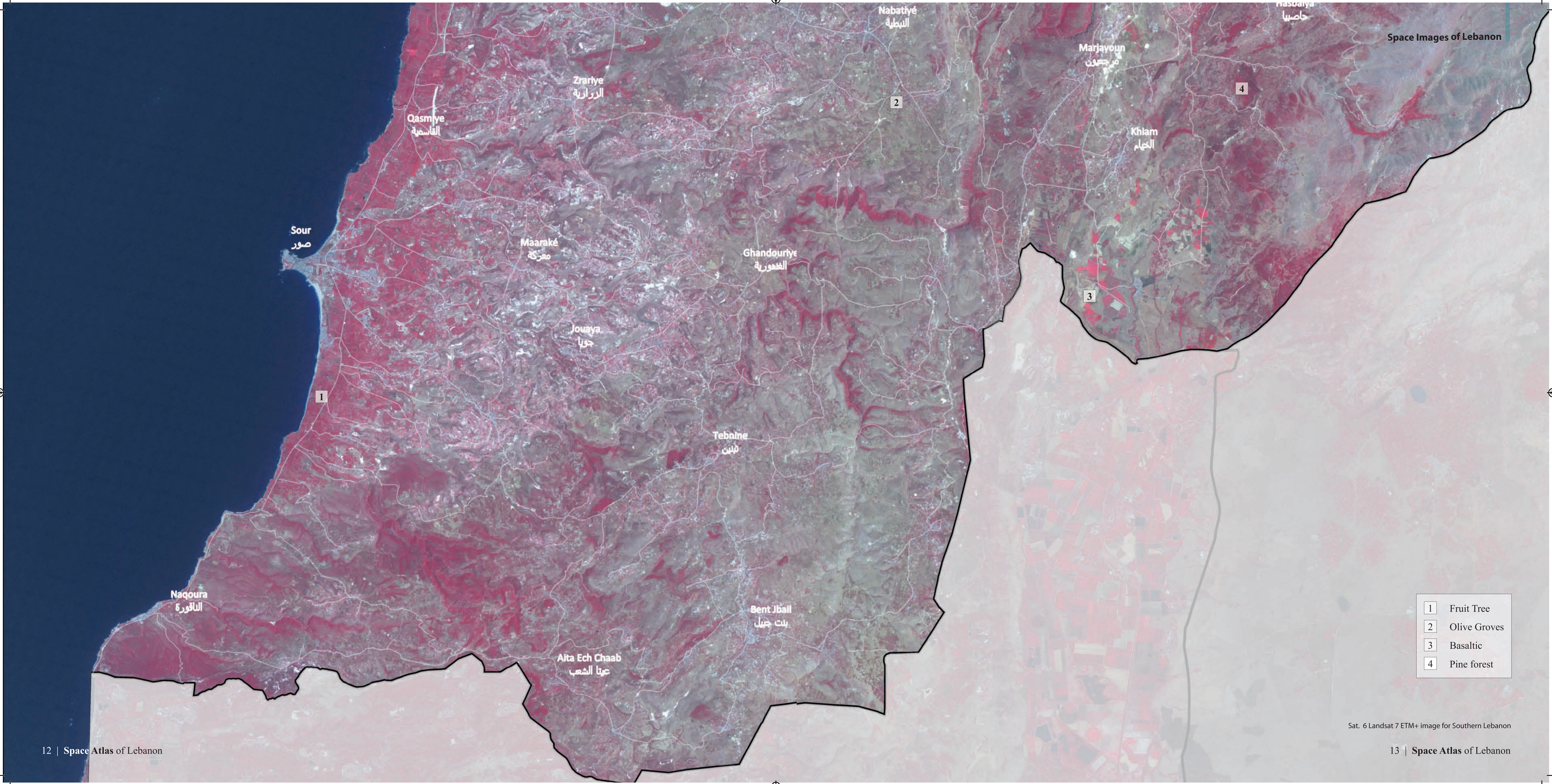
Sat. 3 Landsat 7 ETM+ image for Central Lebanon



Sat. 4 Landsat 7 ETM+ image for Central Lebanon



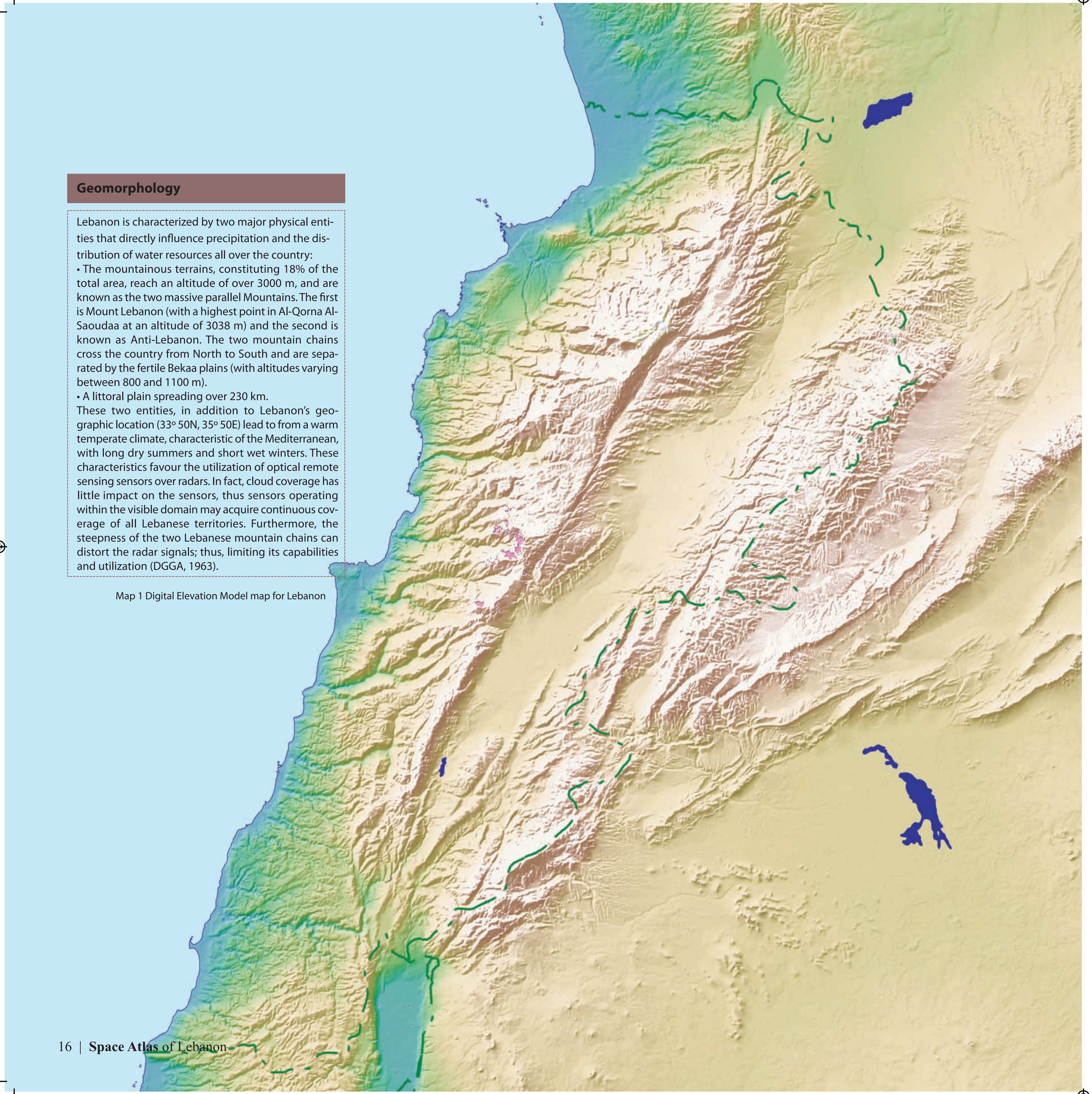
Sat. 5 Landsat 7 ETM+ image for Central Lebanon



Sat. 6 Landsat 7 ETM+ image for Southern Lebanon

Section 2

Physical **Characteristics** Of Lebanon



Geomorphology

Lebanon is characterized by two major physical entities that directly influence precipitation and the distribution of water resources all over the country:

• The mountainous terrains, constituting 18% of the total area, reach an altitude of over 3000 m, and are known as the two massive parallel Mountains. The first is Mount Lebanon (with a highest point in Al-Qorna Al-Saoudaa at an altitude of 3038 m) and the second is known as Anti-Lebanon. The two mountain chains cross the country from North to South and are separated by the fertile Bekaa plains (with altitudes varying between 800 and 1100 m).

• A littoral plain spreading over 230 km.

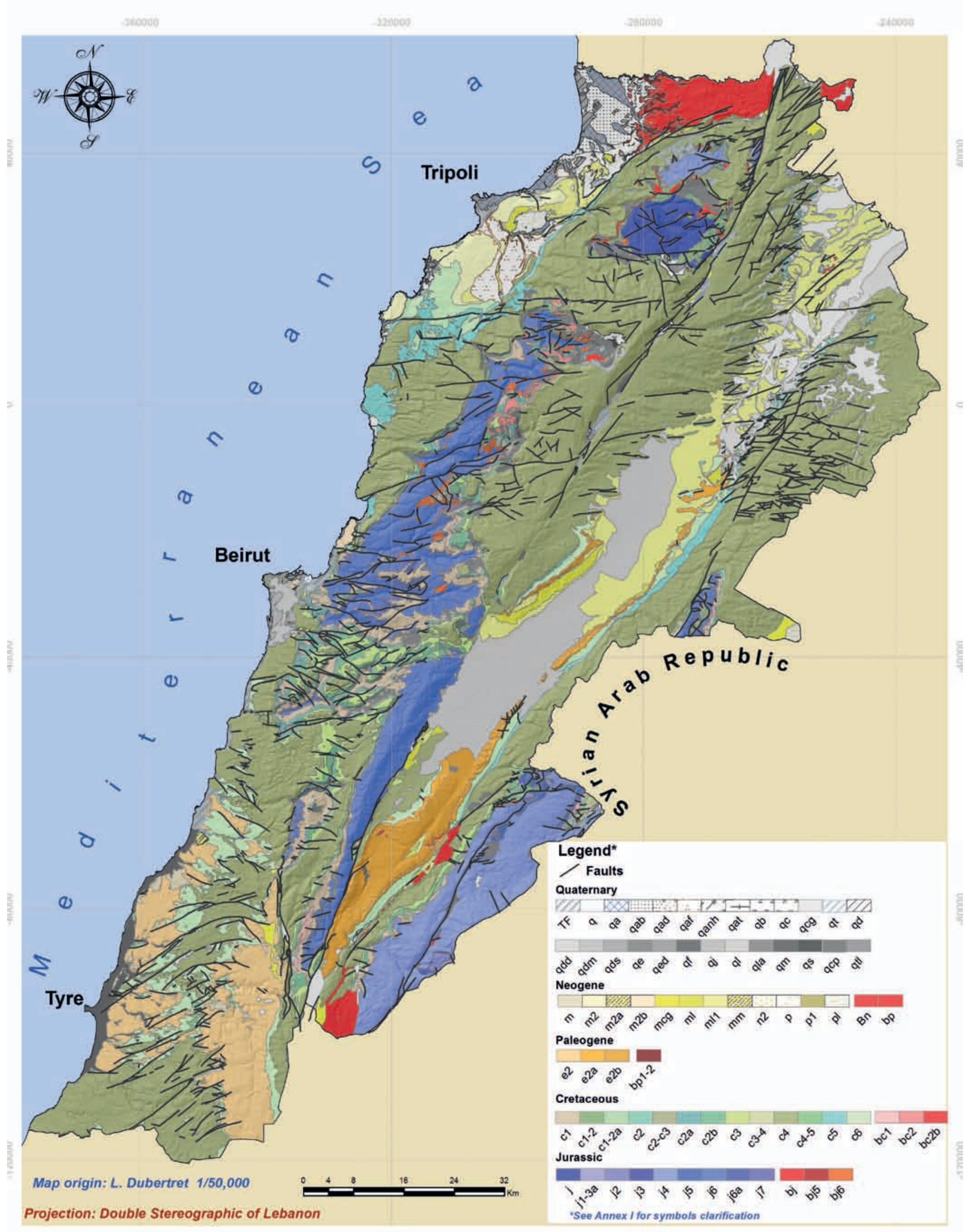
These two entities, in addition to Lebanon's geographic location (33º 50N, 35º 50E) lead to from a warm temperate climate, characteristic of the Mediterranean, with long dry summers and short wet winters. These characteristics favour the utilization of optical remote sensing sensors over radars. In fact, cloud coverage has little impact on the sensors, thus sensors operating within the visible domain may acquire continuous coverage of all Lebanese territories. Furthermore, the steepness of the two Lebanese mountain chains can distort the radar signals; thus, limiting its capabilities and utilization (DGGA, 1963).

Map 1 Digital Elevation Model map for Lebanon

Geology

The geological history of Lebanon is divided into five broad phases, and it is distinguished by varying tectonic and depositional environments. The first episode (probably 250 million years ago) is characterized by the Gondwana break and the drop of the sea level, the second is characterized by the stable deep marine environments, while tectonic activities, volcanic eruptions and sea level drop and rise characterized the third episode. During the fourth episode, the first gentle uplifting of Mount Lebanon and Anti-Lebanon began; thus, the main features of Lebanon started to have shape at this time. The last fifty million years have seen an enormous change in the area, from the Middle Eocene Epoch when the area was covered by shallow seas in which limestones were being deposited to its present state of being an emergent and eroding land mass. Therefore, the oldest surface rocks seen in Lebanon are Early Jurassic, perhaps 200 million years old. This is a very recent age compared with the 4.6 billion years age of earth. The Cenomanian is predominant and constitutes 72 %, followed by the Jurassic with 12%, Eocene 8 % and the Quaternary deposits 8%. These can be recognized from geological maps 1:50000 developed in 1953 by Dubertret (Map. 2). Almost all the rocks in Lebanon are sedimentary rocks and most of these are pale limestones.

The most variable sequence of sediments is that which extends from the Late Jurassic to the Middle Cretaceous and shows a considerable variety of limestones, sandstones, clays and volcanic ashes that tend to weather to a bright red or purple colour and to give fertile soils. There is a hierarchy of folds in Lebanon. The major geological structures of the area, Mount Lebanon, and the Anti-Lebanon are basically two very large NNE-SSW trending anticlines separated by a large syncline, the Bekaa. Additionally, Lebanon is highly fractured and structured geologically. The longest fault in Lebanon is the Yammouneh Fault that runs along the western edge of the Bekaa and links the major fault of the Jordan Valley to the Ghab Valley Fault of Northern Syria. Other major faults are recognized namely, Roum, Hasbaya, Rachaya and Serghaya.



Map 2 Lebanon Geological map 1: 50 000

Geological Features

1. Fractures

Remote sensing can be a helpful tool to identify fracture systems by using several optical and digital advantages. Landsat 7 ETM image showing the huge rock fractures by using digital image analysis. Yellow linear features are the identified fractures.identified fractures)

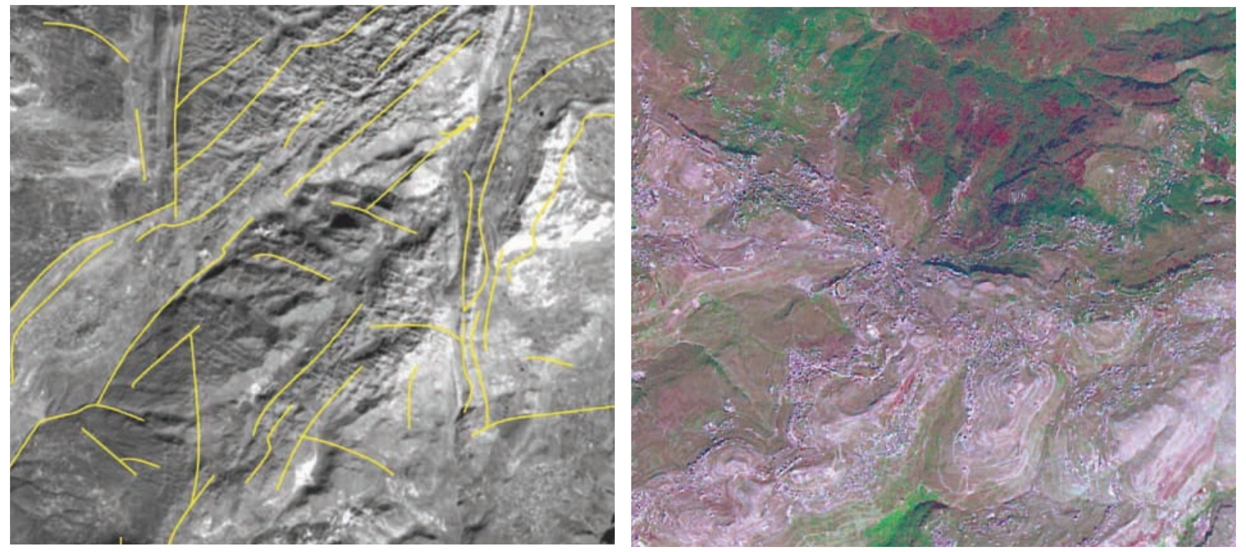


Fig. 1 - a. and b. Identification of huge rock fractures in Lebanon

2.Ring structures

Landsat ETM images showing ring structures on terrain surface in Amioun and Nahr Ibrahim region respectively. The figure reveals the geometric analysis of the identified rings. These structures are attributed either to the existence of plutonic activity or meteoric bodies from outer space that struck the Earth's surface since millions of years.

Satellite images with different optical and spectral properties show different geological structures. There is a ring structure and a number of fractures with different dimensions and orientations. It shows the capability of Remote Sensing in analysing geological aspects and the interpretation of their mechanism.

Fig. 2 - Example of ring structure in Nahr Irahim region

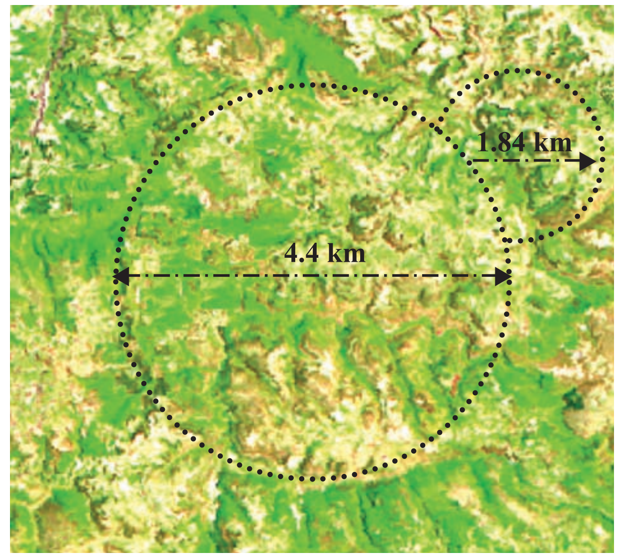


Fig. 3 - Example of ring structure in Amioun region

3. Groundwater potential zones

Landsat ETM image and analysed figure to the same image show a set of hydrological information on the Earth's surface. They show how to manipulate different hydrological elements to identify potential groundwater zones and subsurface flow regimes (Figure 4).

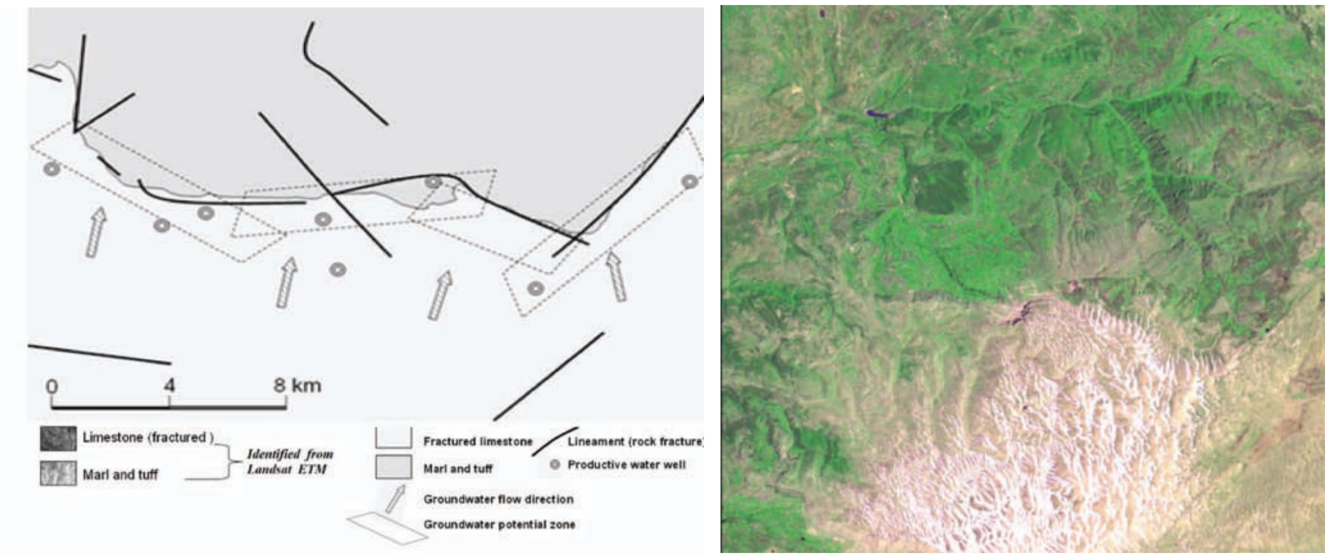
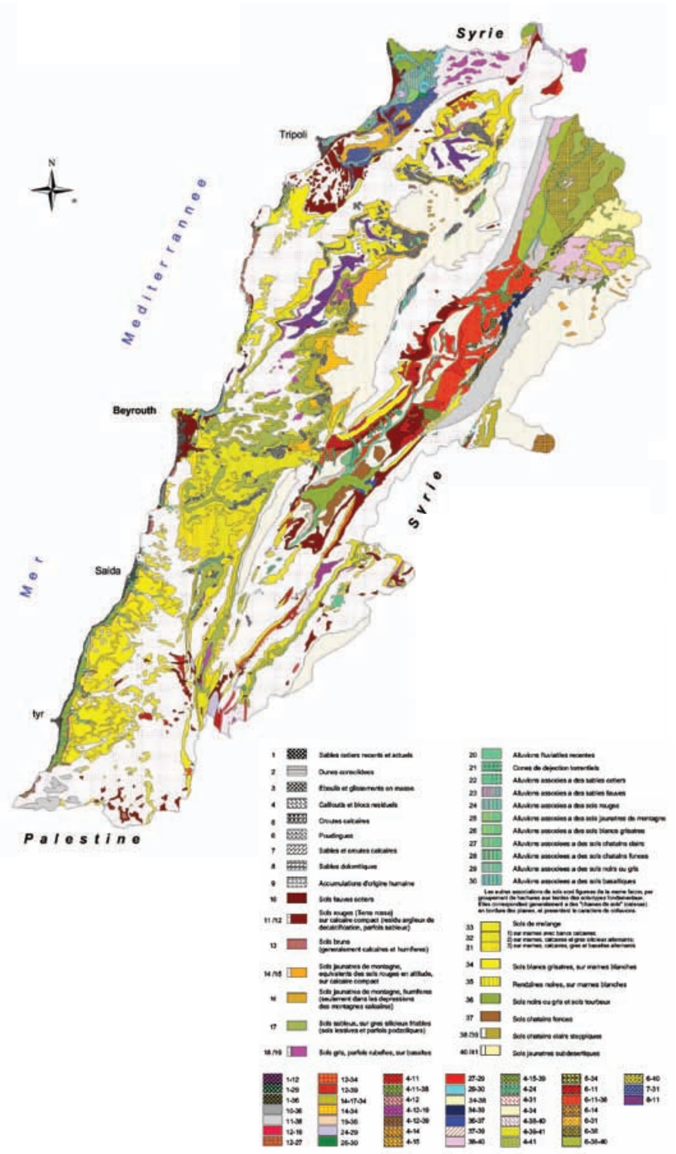


Fig. 4 - Example of groundwater potential zone in Zgharta region

Soil Cover of Lebanon

Lebanon's limited territory has a striking diversity of topography, geology, climate, hydrology and vegetation. Adding the human impact, these result in a remarkable mosaic of soil types that rarely can be found in comparable areas. The first complete soil map of Lebanon was produced by the French Soil Scientist B. Geze in 1956. Geze identified eighty one soil units among which thirty eight soil types were pure types and forty three were soil associations. Among these, thirty four represent an association of two soil types, and nine are formed from association of three soil types. Recent soil studies and projects have been taking place at the NCSR, in cooperation with different universities, such as the American University of Beirut and the Lebanese University. In 1997, with the establishment of the RSC at the NCSR, a new era of soil related activities started with the initiation of mapping of soil resources with the use of RS and integrated information system for the creation of a unified soil map at 1:50,000 scale, and soil terrain database for Lebanon. About 450 soil profiles were detected described, analysed and mapped (Map. 3). Soils were classified according to the WRB, FAO-UNESCO & USDA nomenclatures.



Map 3 - Lebanon soil map 1: 50 000

Soil colour reflects the organic matter and $CaCO_3$ content, as well as the oxidation-reduction status of iron and probably aluminium characterizing the soil organic and mineral content, drainage conditions and hydrological characteristics. These patterns can be deduced and areas delineated from the satellite image.
A total of 11 soil types (major classes) representing the higher soil component containing 113 soil mapping units were identified as shown in the table 1. The Leptosols, famous for being the largest traditional terra-rossa of the Mediterranean Lebanese slopes, occupy the largest area (21.75%). The second largest soil class, Luvisols (19.38%), is distinguished by the prevalence of natural vegetation with lower rates of shift to cultivation. Other soils like Regosols (17.41%), Cambisols (14.17%), spread all over Lebanon, reflecting in a land-cover and land use diversity.

Soil type	Area (Km²)	Percentage %
Andosols	158.13	2.31
Arenosols	371.97	5.42
Anthrosols	426.65	6.22
Calcisols	321.17	4.68
Cambisols	971.92	14.17
Fluvisols	353.79	5.16
Cleysols	166.1	2.42
Leptosols	1491.81	21.75
Luvisols	1328.78	19.38
Regosols	1193.81	17.41
Vertisols	73.47	1.07
Total area	**6857.6**	**100.00**

Table 1 - Soil types in Lebanon

Soil as a natural resources component

Soil is one of the most important natural elements of the earth system and an essential component of land resources. The new soil and terrain database (SOTER) of Lebanon at 1:50,000 scale, represents a tool to elaborate a national soil policy and guidelines for sustainable land use planning.

Example of soil type available in Lebanon are shown in the figures below, as depicted from 1m resolution Ikonos images.

Regosols

When soil Epipedon contains no remarkable features, distinguishing it from the lower soil layers (Endopedon), then the soils are described as Regosols. Regosols almost develop on fan deposits and sediment accumulation at foot slopes, also along drainage and erosion channels or pathways.

Fig. 5 - Regosols

Aridic Leptosols

When aridic properties exist in soils developed under arid climate "e.g. Northern part of the Bekaa valley- Qaa area", these properties are evidence of eolian activity like wind shaped rock fragments and wind caused erosion deposition. Under intensive agricultural activities with ample use of fertilizer and water input, secondary soil salinity may develop showing white soil surface "easily detected by remote sensing", as a result of salt accumulation.

Fig. 6 - Aridic Leptosols

Andosols

Andosols are highly porous, dark-coloured soils of volcanic origin, such as basaltic ash, tuff, and pumice. Worldwide they are estimated to be less than 1 percent of the total soil area on Earth's surface. In Lebanon, they occur mainly in the Northern part (e.g. Akkar, Halba plateau), the central mountains, Hasbaya and Khiam area. These soils are clayey and non-calcareous

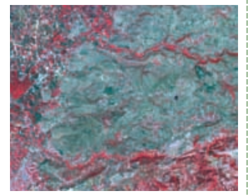


Fig. 7 - Androsols

Fluvisols

These soils developed from fluvial deposits on rivers banks and have uneven clay, gravel and organic matter. They are usually deep and very deep, productive, clayey with different $CaCO_3$ content.

Fig. 8 - Fluvisols

Leptosols

These shallow soils (<50 cm) developed on limestone rocks. they have good drainage with dominant stoniness and rockiness (gravel content exceeds 80%). When a Leptosol is <10 cm in depth it becomes a Lithic Leptosol. Sloping lands and Karst areas associated with Leptosols represent the main recharge zones for groundwater in Lebanon.

Fig. 9 - Leptosols

Anthrosols

The soil is classified as an Anthrosol when it results from human activity (e.g. terracing, deepening, long time addition of organic materials). Figure 11 shows the terracing in the South area.

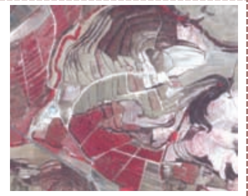


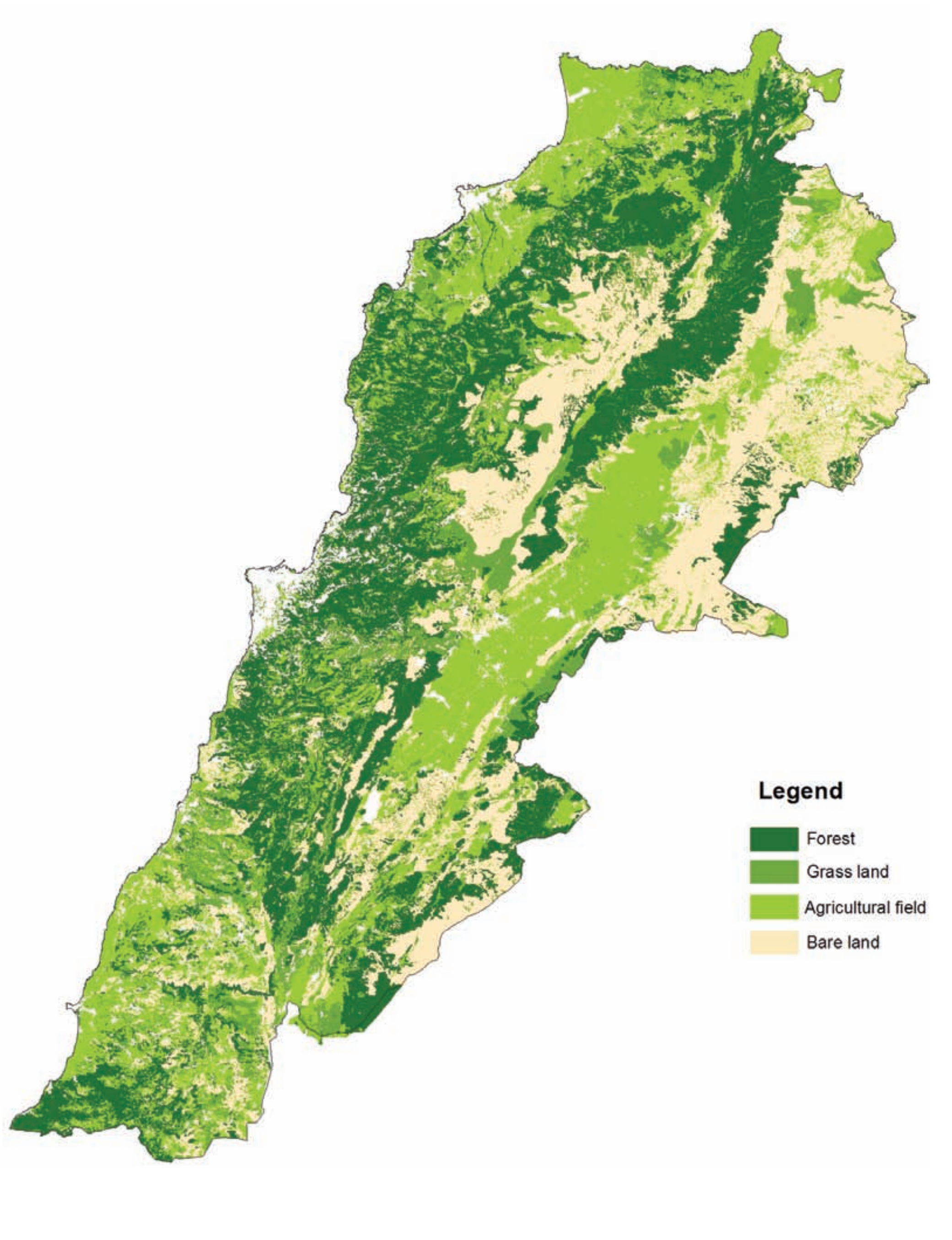
Fig. - 10 Anthrosols

Section 3

Natural Resources Of Lebanon

Forest land

Forests in Lebanon represent a unique feature in the generally semi-arid environment of the Eastern Mediterranean. In 2002, forests covered 139,376 ha while Other Wooded Lands (OWLs) covered 108,378 ha, 13.3 % and 10.37 % of the surface area of the country respectively. Other lands with trees (including fruit and olive trees) covered a surface of 116,210 ha (11.1%) of the surface of the country. The forest cover is broadly divided into three main classes: mixed forests (15,610 ha), broadleaves (78, 887 ha) and coniferous (44,879 ha). On the other hand, OWLs are divided into the following classes: coniferous shrubs, broadleaved shrubs, mixed shrublands and grassland with trees (MoA/FAO, 2005). The main forests in Lebanon are Quercus calliprinos, Quercus infectoria, Quercus cerris (mostly referred to as Quercus spp), Juniperus excelsa, Cedrus libani, Abies cilicica, Pinus pinea, Pinus halepensis, Pinus brutia and Cupressus sempervirens.



Map 4 - Lebanon forest cover map 1:50 000

Agricultural Land

High resolution satellite images such as IKONOS (1m resolution) images help providing information on the surface areas such as the number of greenhouses as well as the chapels cultivated mainly by vegetables, floriculture and banana.

In this respect, areas cultivated with olive trees were estimated at 58.8 thousand hectares (22% of the total cultivated area) for the year 2005. The largest portion of the this is found in the North (40%), followed by Nabatiyeh (20%), the rest of the South (18%), Mount Lebanon (17%) and the Bekaa (5%). Cereals were estimated for 65.2 thousands ha for the same year.

The most important cultivated cereals in Lebanon are: wheat, barley and corn.

The Bekaa plain occupies the forefront in terms of cultivated cereals' area in Lebanon (59%) followed by the North (Akkar plain) with 20%.

The most important citrus crops in Lebanon are: oranges (236 thousand tons produced), lemons (113 thousand tons produced) and clementines (31 thousand tons produced).

Grassland and Barerock

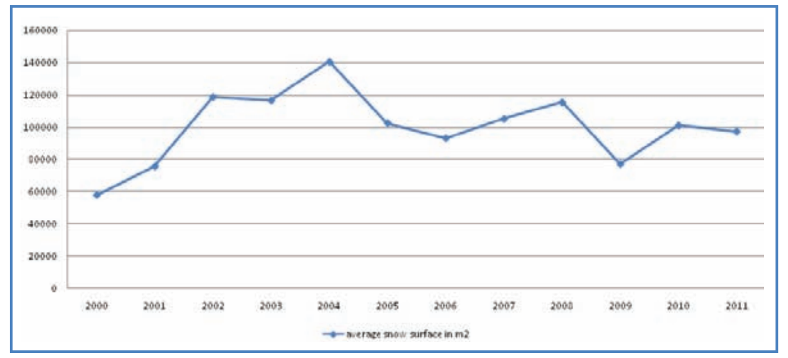
Under good and favourable environmental conditions, such as gentle slopes, warm temperature and available moisture; grasslands cover almost 10.44 % of the land cover of Lebanon with a 139,779 km². The major grasslands are found along the water courses, generally between 250 and 800 metres asl. In addition, they can be found as large patches surrounding forest areas or in small ones between the forest trees or close to water bodies. In elevated zones, these tend to make a small layer and disappear where bare rock exists.

Water Resources

Lebanon, the so-called the water tower, is distinct from other countries in the Middle East through its extensive water networks. Lebanon has a number of artificial lakes, the Qaraoun Lake is the largest one (~5km2), located in the south of the Bekaa valley. There are 17 permanent rivers. Three of them are inner ones and originated from the Bekaa plain while two of them do not flow into the sea; these are the Hasbani and Assi Rivers. The massifs of Mount Lebanon and Anti-Lebanon form enormous masses of porous and water absorbing limestone. They contribute to the formation of groundwater in large volumes. The main sources are located at altitudes varying between 1200 and 1500 m as those of Afqa and Aqoura, or buried in valleys such as Jeita or Antelias.

Snow Cover

In Lebanon, there is, annually, a maximum of 89 snowy days according to the data of 13 years between 2000 and 2012. These values can range from a single day or even none, on the coastal area, the North Eastern and the South, to reach the maximum on the highest peaks of Mount Lebanonsuch as Al-Korna Al-Sawdaa. This reflects the diversity of Lebanese climate and the dissimilarity in his topography.



Graph 1 - shows the average annual distribution of the snow between 2000 and 2011.

Monitoring of the Lebanese Coastal Waters

The National Center for Marine Sciences conducts, since 1977, a monitoring program of the Lebanese coastal waters. 25 sites reflecting the geomorphological and environmental aspects of the littoral are sampled monthly. Measurements of physico-chemical, chemical, bacteriological and biological indicators are carried out in order to evaluate the pollution level and to document the changes of the littoral.

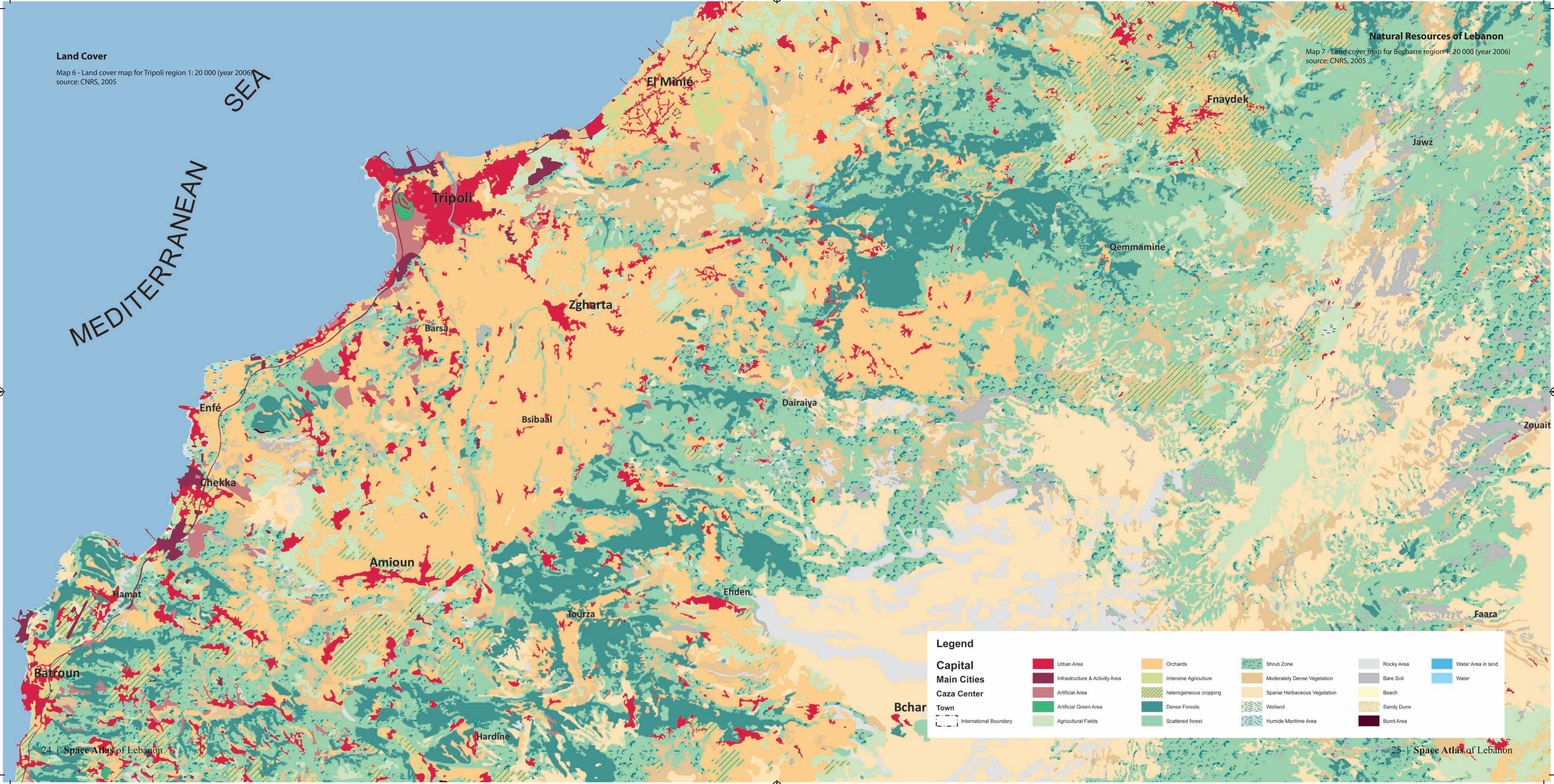
Map 5 - Lebanon Water resources map 1:50 000 showing the quality of the water on different sites along the Lebanese coast Sewage flowing on the sea Development of marine green macroalgae due to organic pollution.

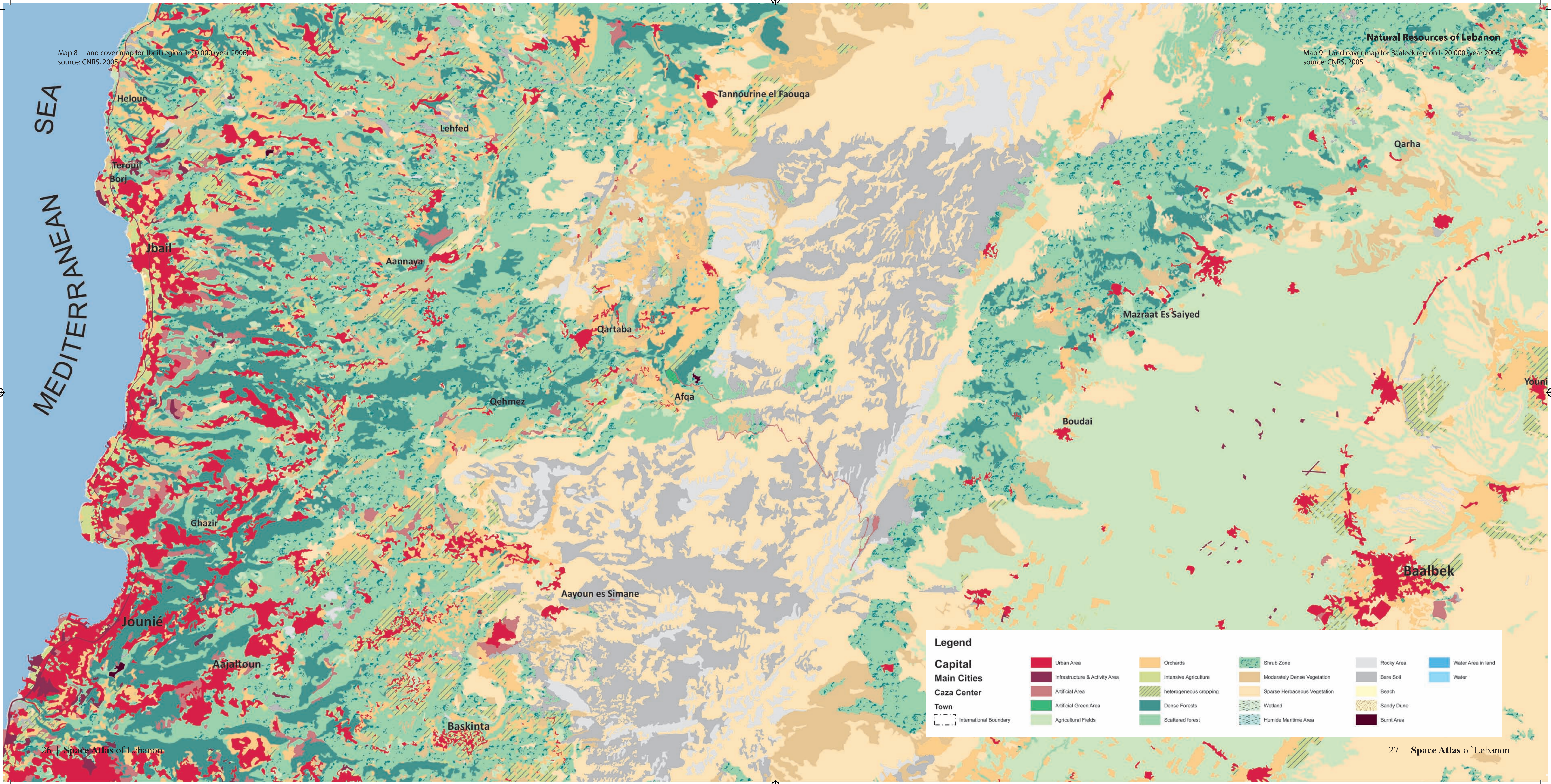
Land Cover

Map 6 - Land cover map for Tripoli region 1: 20 000 (year 2006)
source: CNRS, 2005

Natural Resources of Lebanon

Map 7 - Land cover map for Becharre region 1: 20 000 (year 2006)
source: CNRS, 2005



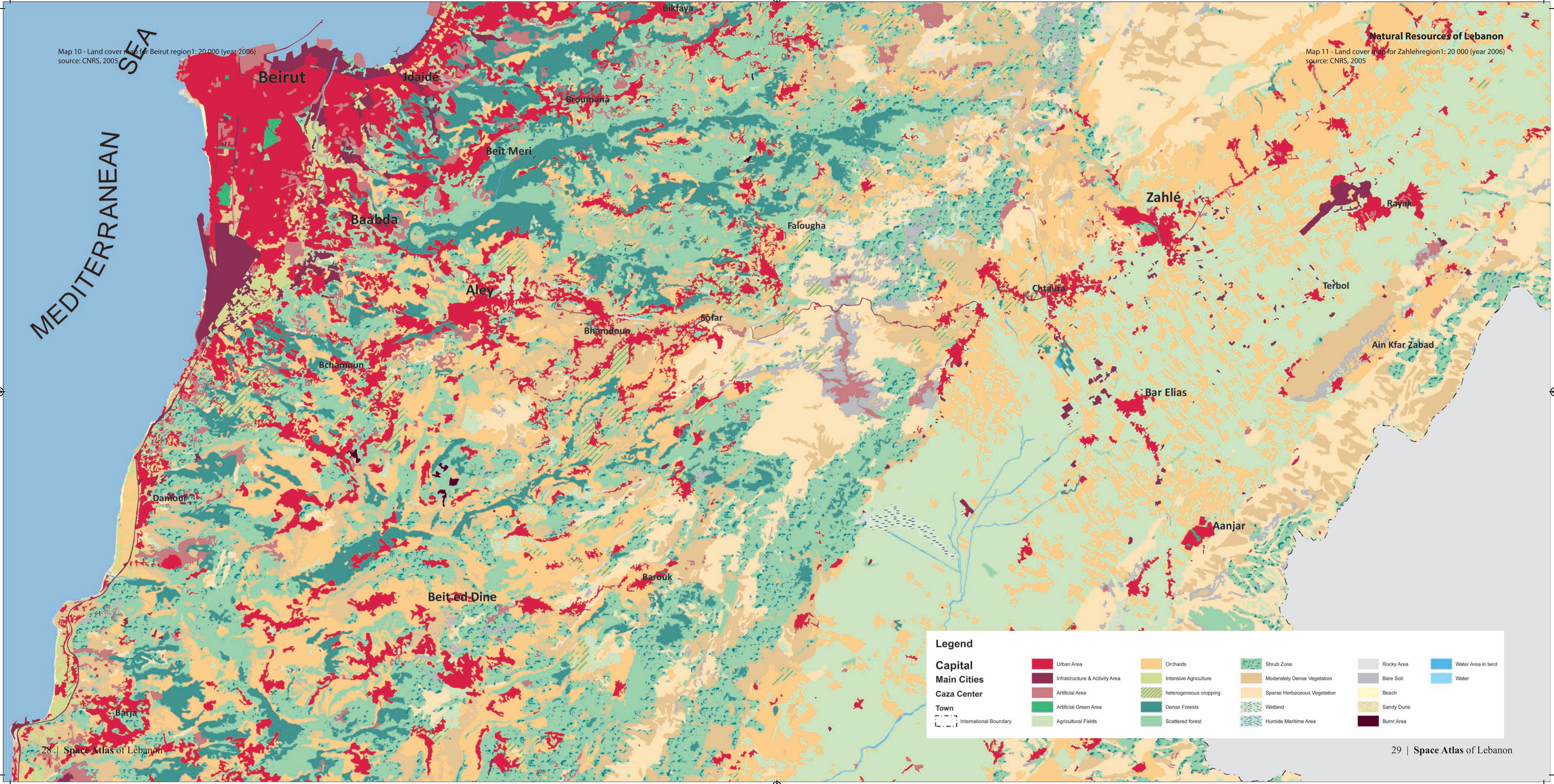


Map 8 - Land cover map for Jbeil region 1: 20 000 (year 2006)
source: CNRS, 2005

Map 9 - Land cover map for Baaleck region1: 20 000 (year 2006)
source: CNRS, 2005

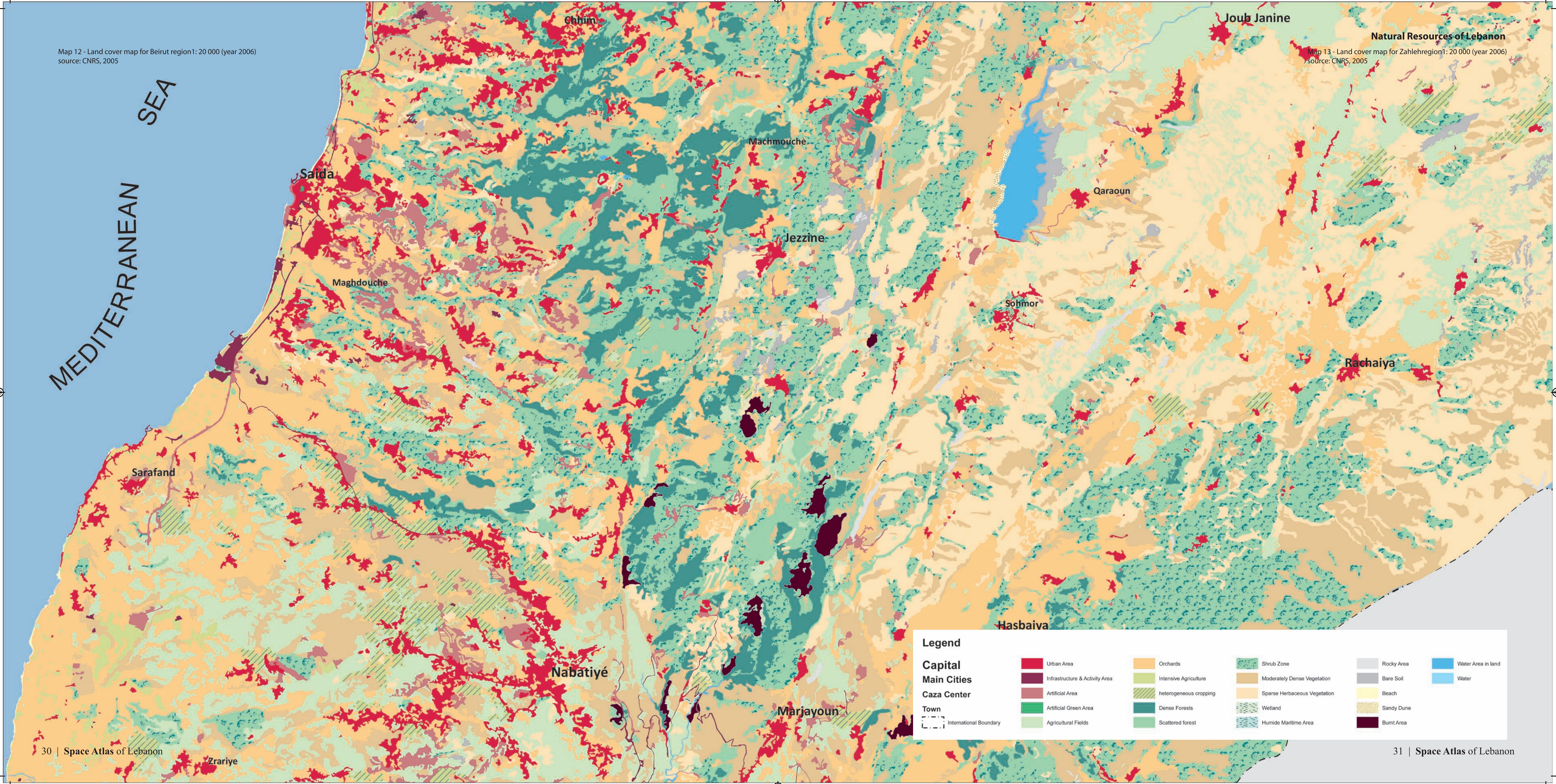
Map 10 - Land cover map for Beirut region1: 20 000 (year 2006)
source: CNRS, 2005

Map 11 - Land cover map for Zahlehregion1: 20 000 (year 2006)
source: CNRS, 2005



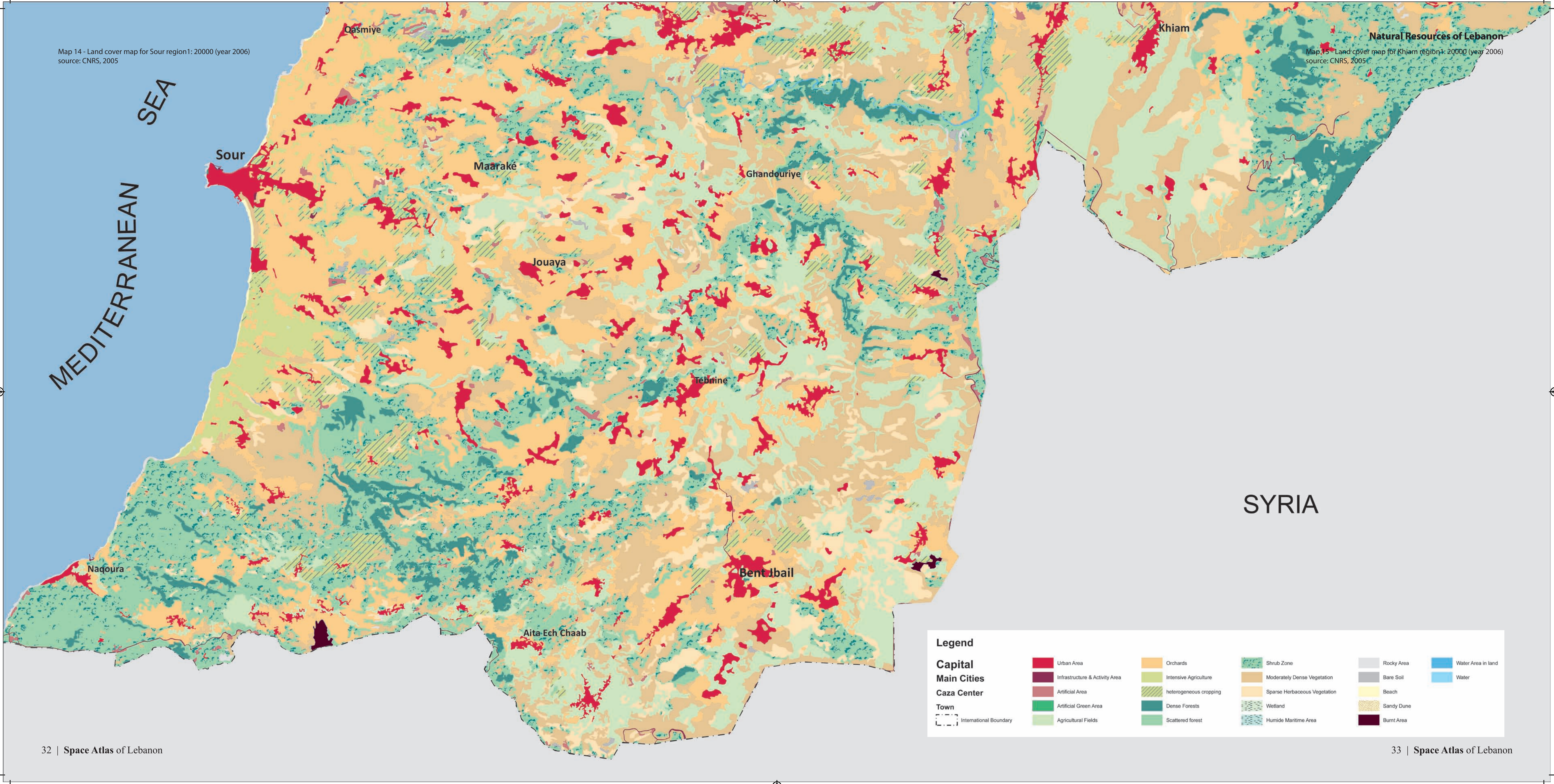
Map 12 - Land cover map for Beirut region1: 20 000 (year 2006)
source: CNRS, 2005

Map 13 - Land cover map for Zahlehregion1: 20 000 (year 2006)
source: CNRS, 2005



Map 14 - Land cover map for Sour region1: 20000 (year 2006)
source: CNRS, 2005

Map 15 - Land cover map for Khiam region1: 20000 (year 2006)
source: CNRS, 2005



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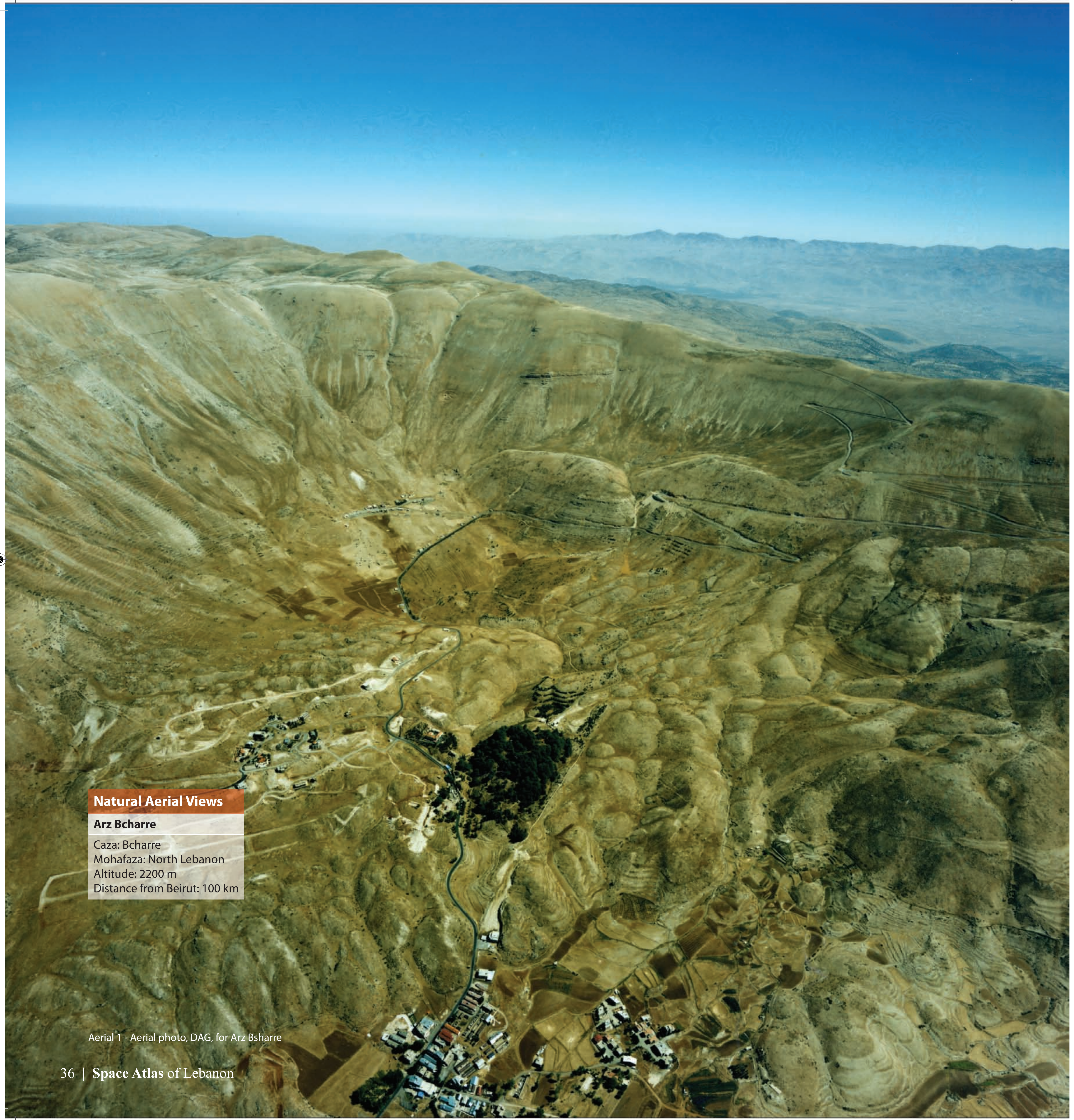
Section

4

Landscape **& Cultural** Heritage



Natural Aerial Views

Arz Bcharre

Caza: Bcharre
Mohafaza: North Lebanon
Altitude: 2200 m
Distance from Beirut: 100 km

Aerial 1 - Aerial photo, DAG, for Arz Bsharre

Amioun

Caza: Koura
Mohafaza: North Lebanon
Altitude: 350 m
Distance from Beirut: 0 km

Aerial 2 - Aerial photo, DAG for Amioun

Chekka

Caza: Batroun
Mohafaza: North Lebanon
Altitude: 0 m
Distance from Beirut: 55 km

Aerial 3 - Aerial photo, DAG for Chekka

Douma

Caza: Batroun
Mohafaza: North Lebanon
Altitude: 1500 m
Distance from Beirut: 70 km

Aerial 4 - Aerial photo, DAG for Douma

Aerial 5 - Aerial photo, DAG for Jbeil

Aerial 6 - Aerial photo, DAG for Jounieh

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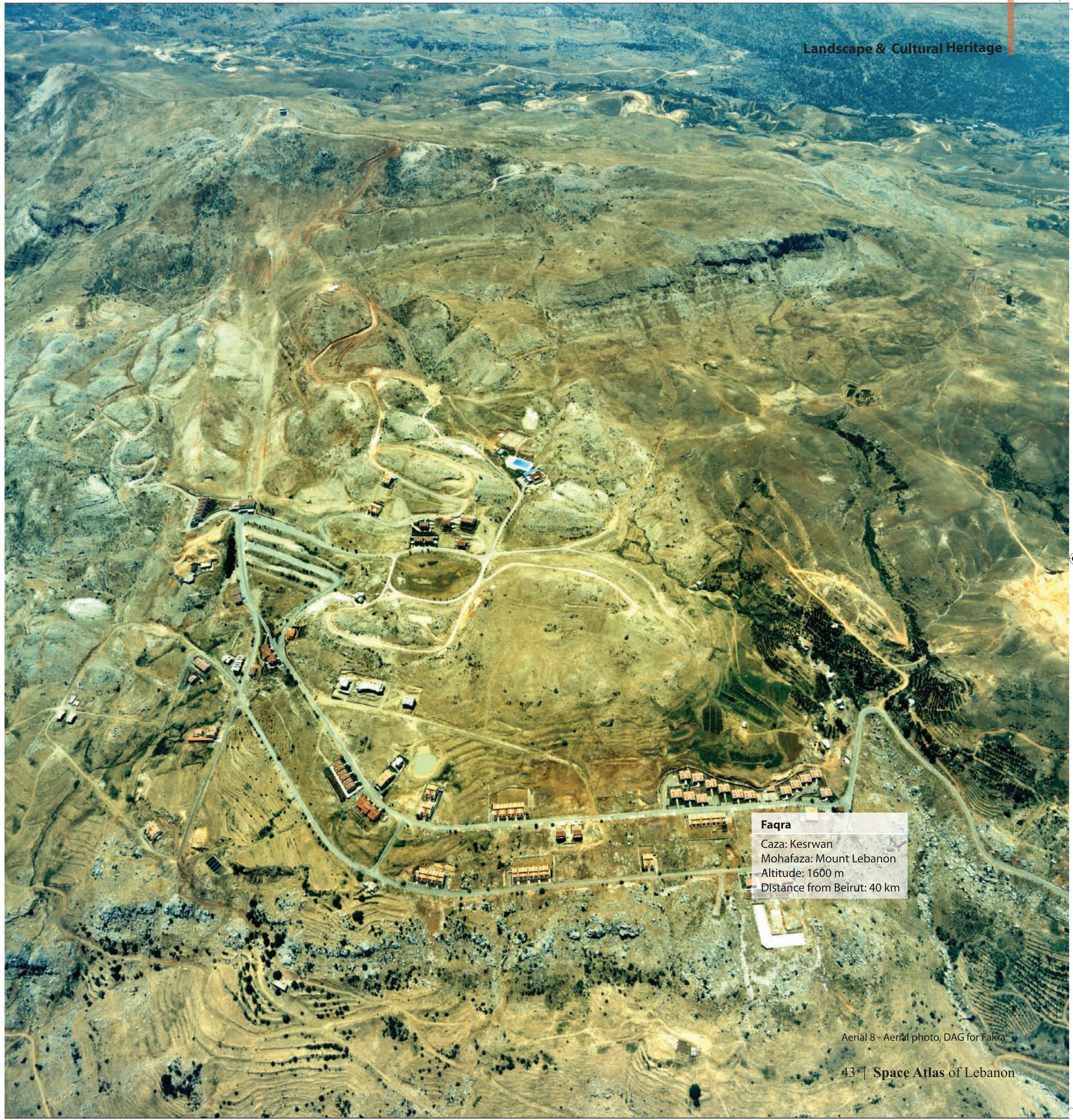
Aerial 7 - Aerial photo, DAG for Jounieh



Aerial 8 - Aerial photo, DAG for Fakra

Aerial 9 - Aerial photo, DAG for Bekfaya

Aerial 10 - Aerial photo, DAG for Beirut

Rawcheh

Mohafaza: Beirut

Aerial 11 - Aerial photo, DAG for Rawcheh

Bar Elias

Caza: Zahle
Mohafaza: Beqaa
Altitude: 900 m
Distance from Beirut: 40 km

Aerial 12 - Aerial photo, DAG for Bar Elias

Aerial 13 - Aerial photo, DAG for Aley

Photo 1 - Kadisha Valley

Archaeological Sites

Qadisha Valley and Cedars of God

Lebanon's deepest valley (Wadi), Qadisha is a world Heritage site since 1998. Above it respite the famous Cedar forest of Bsharri called "Cedars of God and towers Al-Qorna Al-Saoudaa, Lebanon's highest peak.
"Qadisha" means "holiness" in Semitic languages, consequently, Wadi Qadisha means the "Holy Valley".
The valley was inhabited since prehistoric times and during the beginning of the Christian era. It housed many early Christian monastic settlements, among others, rock-cut chapels, grottoes, and hermitages, many painted with frescoes dating back to the 12th and 13th centuries. Wadi Qadisha and the Cedars of God have been included in the World Heritage List of the Convention concerning the Protection of the World Cultural and Natural Heritage in 1998. Inclusion on this List confirms the exceptional universal value of this cultural and natural site and requires its protection for the benefit of all humanity.

Sat .7 - IKONOS satellite image for Kadisha Valley for the year 2005

Photo 2 - Anjar

Sat. 8 - IKONOS satellite image for Anjar for the year 2005

Aanjar

Aanjar, 58 km from Beirut, lies in the middle of some of the richest agricultural lands in Lebanon. It dates exclusively from one period, the Umayyad dynasty. Aanjar is considered as the only historic example of an inland commercial centre. The city benefited from its strategic position on intersecting trade routes leading to Damascus, Homs, Baalbak, and the south.

Photo 3 - Baalbeck

Sat .9 - IKONOS satellite image for Baaleck for the year 2005

Baalbeck

Situated in the centre of the fertile Bekaa valley, between the Mount Lebanon chain to the West and the Anti-Lebanon to the East, Baalbak temple complex was on the crossroad of two main historic trade routes, one between the Mediterranean coast and the Syrian inland and the other between Northern Syria and Northern Palestine. Roman temples, Islamic structures and many archaeological remains dating from different historical periods transformed Baalbak into a real open-air museum. Baalbak was the major construction project Emperor Augustus the founder of the Roman Empire and his successors ever made in the East. It was then transformed into an important cultural and pilgrimage place, in addition to being an essential meeting point of all the caravans crossing the Bekaa. Consequently, Baalbek was transformed into a central place for the dissemination of the Roman civilization and to show the power of Rome to the inhabitants of the region.

Photo 4 - Byblos

Byblos

Located 37 kilometres north of Beirut, Jbeil or Byblos is the oldest continuously inhabited city on the Lebanese coast. According to Phoenician belief, it was founded by the god "EL". For several centuries, it was called "Gubla" and later "Gebal," while the term "Canaan" was applied to the coast in general. Within the old town of Byblos, medieval Arab and Crusader remains are continuous reminders of its recent past.
Before Byblos was excavated, the successive layers of the ancient ruins had formed a mound about 12 meters high covered with houses and gardens. The proper excavations of the site began in 1921-1924 by Pierre Montet, a French Egyptologist. Afterwards, Maurice Dunand continued his work in 1926 and undertook numerous excavation campaigns until 1975.
These extensive excavations made Byblos one of the most important archaeological sites in the region.

Legend
1. The city gate
2. Old fortification wall
3. The great temple
4. The Roman road
5. Temple of the Obelisks
6. Ain el-Malik
7. Residential complex
8. Small house
9. Oval house
10. Monocellular house
11. Apsidal house
12. Monocellular house
13. The Amorite quarry
14. Bronze Age house
15. The temple of Baalat Gebal
16. The Roman theater
17. Shaft tomb
18. Residential
19. Roman colonade
20. Fortification wall
21. City fortification
22. Roman Nympheum
23. The crusader castle
24. persian castle

Sat. 23 - IKONOS satellite image for Byblos for the year 2005

Photo 5 - Tyre

Tyre

One of the earliest metropolises, Tyre enjoys exceptional universal value and outstanding characteristics; it is the place where, according to legend, the purple dye was invented, and where the great Phoenician city ruled the seas and founded prosperous colonies such as Cadiz and Carthage. Its historical role declined at the end of the Crusades. It conserves important archaeological remains, mainly from Roman times.
Because of its exceptional value, Tyre was nominated World Heritage Site in 1984. The inscription of Tyre on the World Heritage List demonstrates the recognition bestowed upon Tyre by the international community and the need to safeguard its heritage for future generations.

Al Bass Site
1. The Byzantine Road
2. Churche With Garden
3. The Arcade Tomb
4. The Columbarium
5. Tomb With elevated structure
6. Funerary Chapel
7. The Mosaic Tomb
8. The Monumental Arch
9. The Roman Road
10. Side Way Pedestrian Road
11. Aqeduct
12. The Hyppodrome
13. The Sepulchral Founatain
14. The Bleu team stucture
15. Crusader churche

Sat .24 - IKONOS satellite image for Tyr for the year 2005

Nature Reserves (NR)
Palm Island Natural Reserve

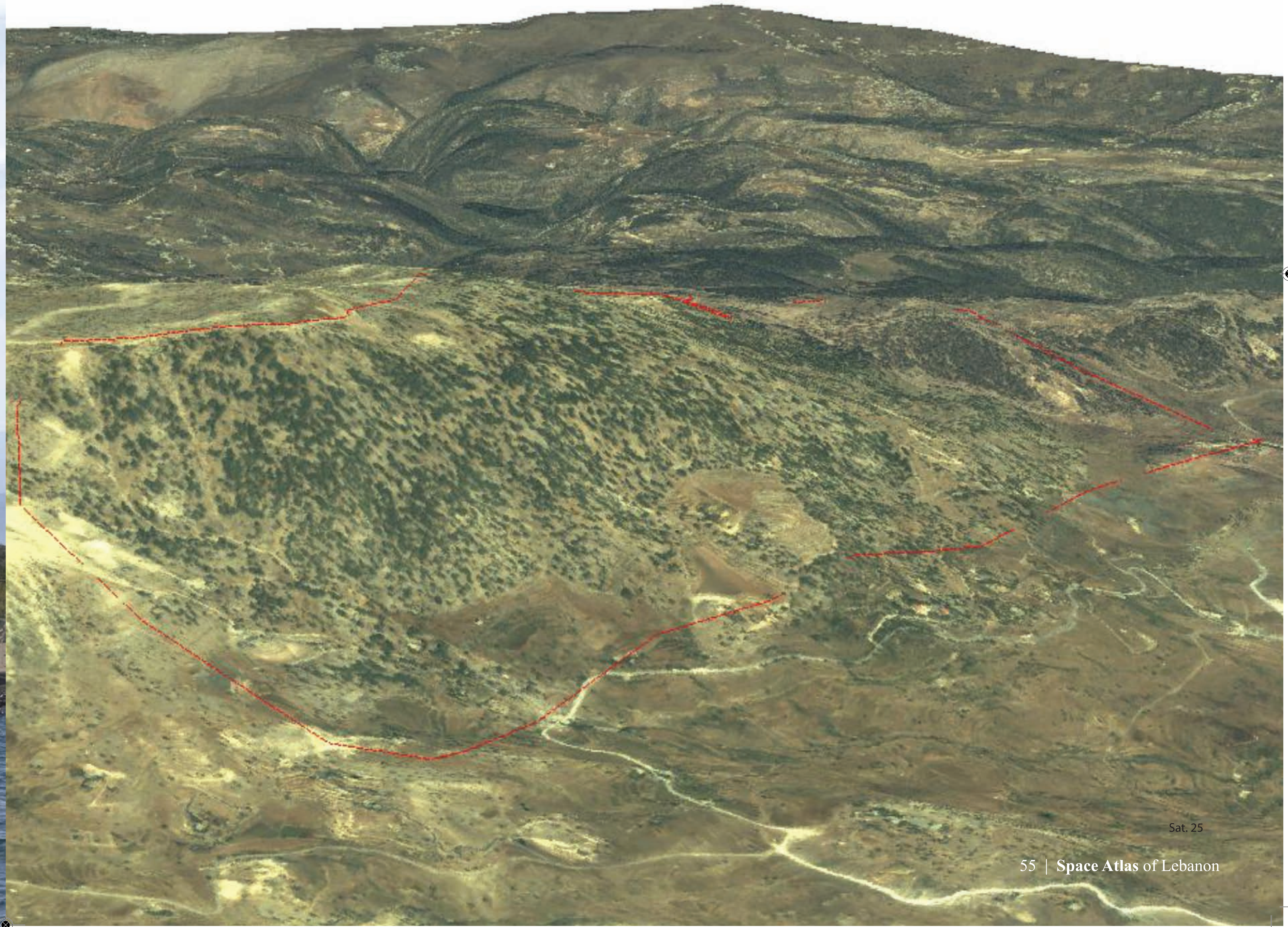
Located northwest of Tripoli, Sanani, Ramkine and Palm Islands together with their surrounding sea represent the Palm Islands NR.). It is also called the "Rabbit Island" because it used to host a large population of introduced domestic rabbits which have been removed later on in respect of the ecological integrity of the site. Due to its special characteristics, Palm Islands Nature Reserve has been designated as a Mediterranean Specially Protected Area according to the Barcelona Convention, an Important Bird Area (Bird life International).

Photo 6 - Palm island Nature reserve

Karm Chbat Forest Natural Reserve

Located at the border between Akkar and Hermel, Karm Shbat NR is a dense Cedar forest. The site has been declared under protection by decision from the MoE in 1995 to acknowledge for the site importance and priority need for conservation. Since land property and ownership in this area is rather unclear, local families are living on site. Additionally, limits of the protection decision are not precise. Since access to site is complicated due to the specific situation of the region, little is known about biological diversity and richness of the forest.

Sat .13. IKONOS satellite image for Karm Chbat Cedar Nature reserve for the year 2005

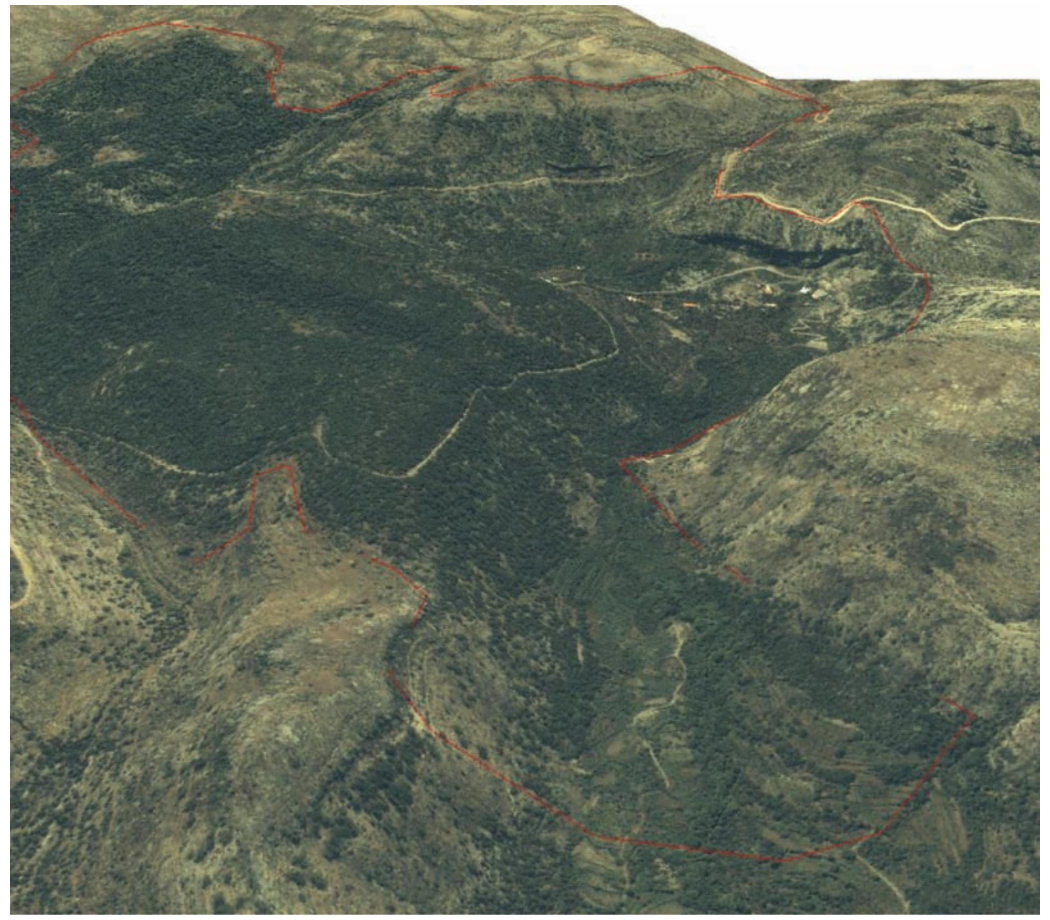


Sat. 25

Horsh Ehden Nature Reserve

Situated on the upper north western slopes of Mount Lebanon, ranging from 1200 m to 2000 m in altitude, Horsh Ehden NR extends over 3 bio-geographic zones, and offers a unique assemblage of conifers, deciduous and evergreen broadleaf trees with a highly variable topography. The forest ecosystem accounts for high biological diversity as it hosts nearly 40% of total plant species present in Lebanon, 26 mammals species, 156 bird species and over 300 different fungi.
The Reserve holds utmost conservation priorities since the Cedrus libani forest represents about 20% of the remaining cedar forests in Lebanon.

Photo 7 - Horsh Ehden Nature Reserve

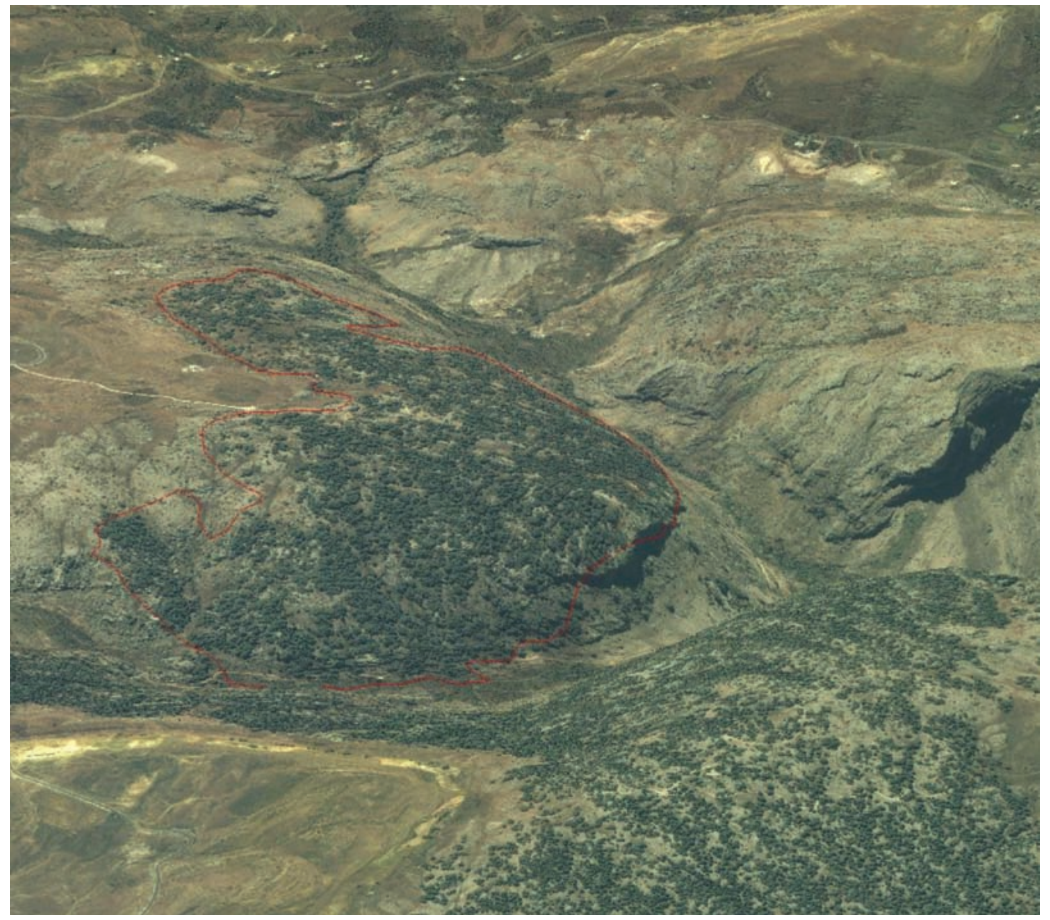


Sat .13. - IKONOS satellite image for Horsh Ehden Nature Reserve for the year 2005

Tannourine Cedar Forest Nature Reserve

Located in North Lebanon at about 85 km from Beirut, with altitudes ranging between 1300 to 1850 meters above sea level, Tannourine Cedar Forest NR extends exclusively over municipal land belonging to Tannourine Municipality and is surrounded by private forests and Religious Endowment properties (Wakf). The exact extent of the area under protection cannot be precisely determined but is estimated to approximately 150 ha. It is the most continuous Cedar forest in Lebanon.
The rocky topography of the site resulted in important diversity in terms of ecosystems, and micro ecosystems where Cedar trees grow on extremely steep slopes.
Out of the 300 plant species found in the reserve, 23 are endemic (SETS, 2007).
Moreover, the presence of 16 species of mammals has been recorded, and this confirms the importance of this reserve for wild life conservation.

Photo 8 - Tannourine Cedar Forest Nature Reserve

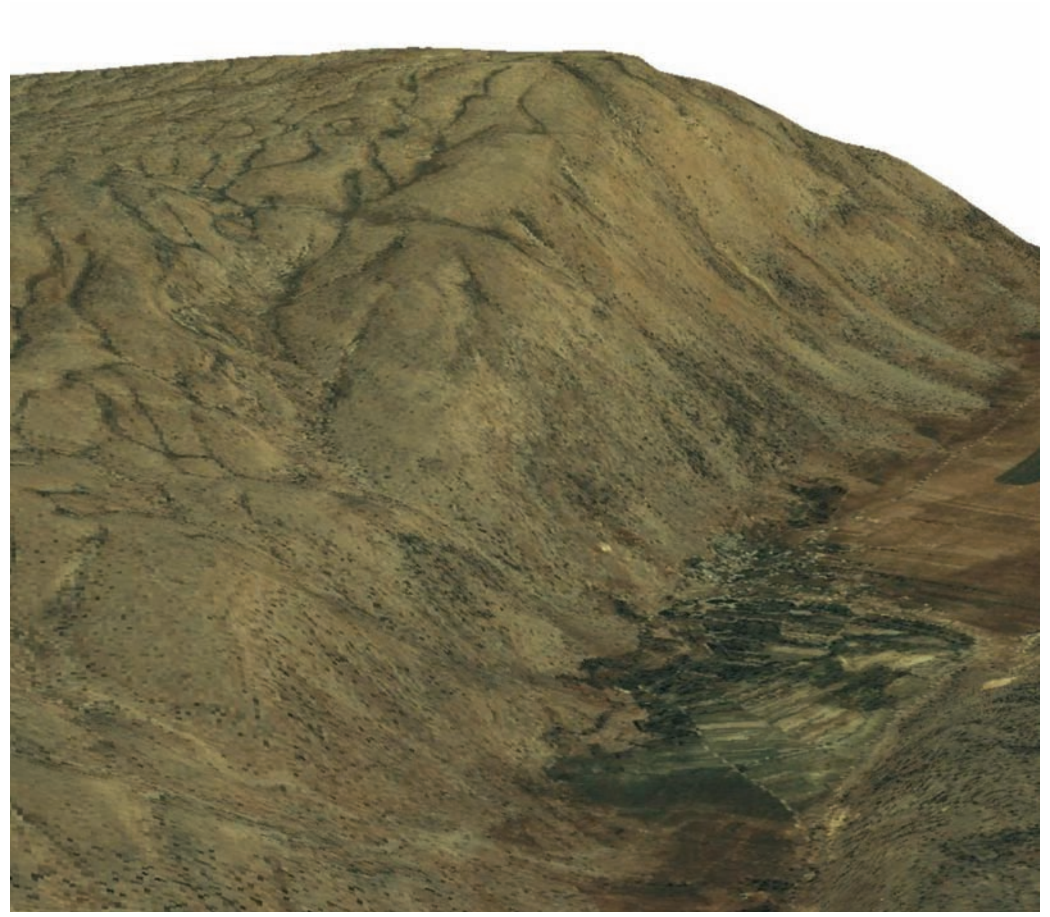


Sat . 14 - KONOS satellite image for Tannourine Cedar Forest Nature Reserve for the year 2005

Yammouneh Nature Reserve

Known for its major fault and temporary wetlands, the Yammouneh NR is also rich in terms of forest cover as it hosts one of the largest juniper forests of Lebanon. The forest has been protected since 1999 by virtue of a law text, however, to date; land ownership conflicts have delayed effective management of the reserve.

Photo 9 - Yammouneh Natural Reserve

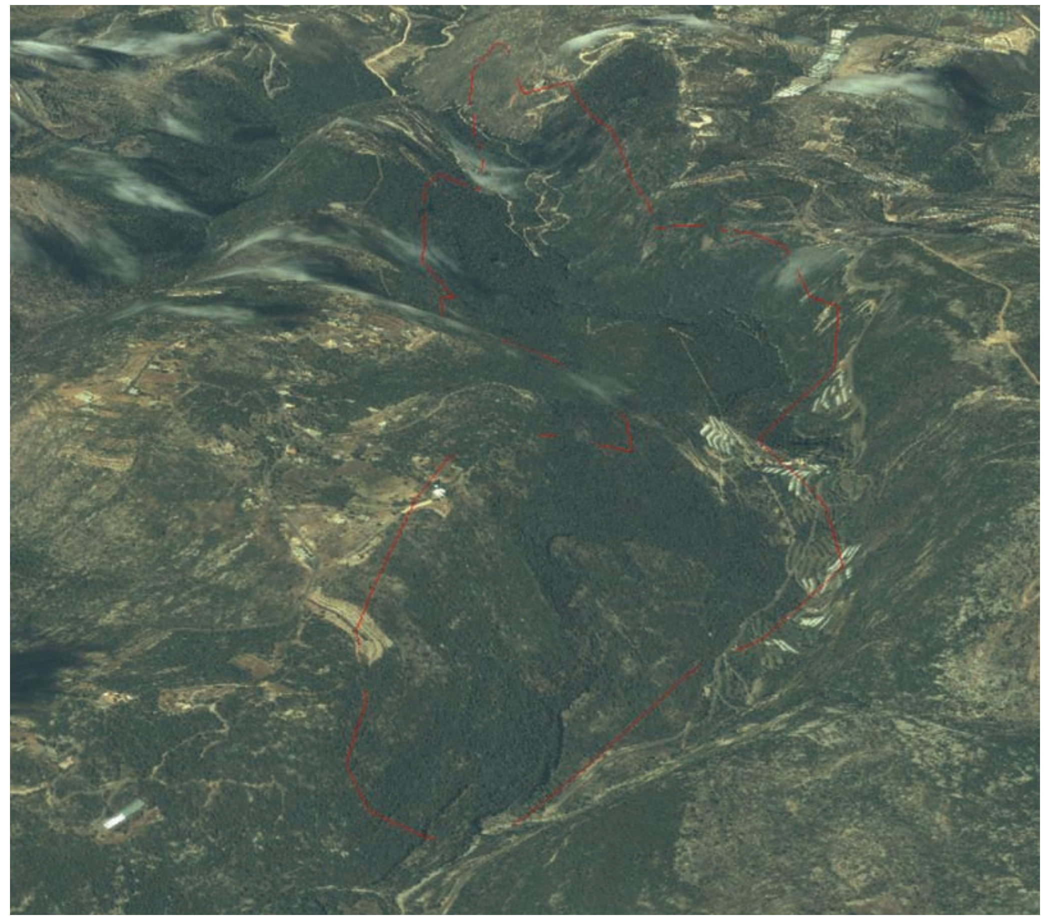


Sat . 15 - IKONOS satellite image for Yammouneh Natural Reserve for the year 2005

Bentael Nature Reserve

Located at the foothills of Mount Lebanon northeast of Jbeil (Byblos), Bentael NR is the smallest NR in Lebanon (1.5 km^2), and one of the first reserves to be established in Lebanon following the initiative of local inhabitants of the village of Bentael to conserve their natural heritage. It was even declared by a local NGO as a Natural area since 1981, almost 20 years before its official declaration as a protected area.
Mainly dominated by pine ecosystems, and located on the flight path of the migratory hawk and other raptors, Bentael NR is the only protected forest ecosystem situated at low to medium altitudes ranging from 350 to 800 m.

Photo 10 - Bentael Natural Reserve

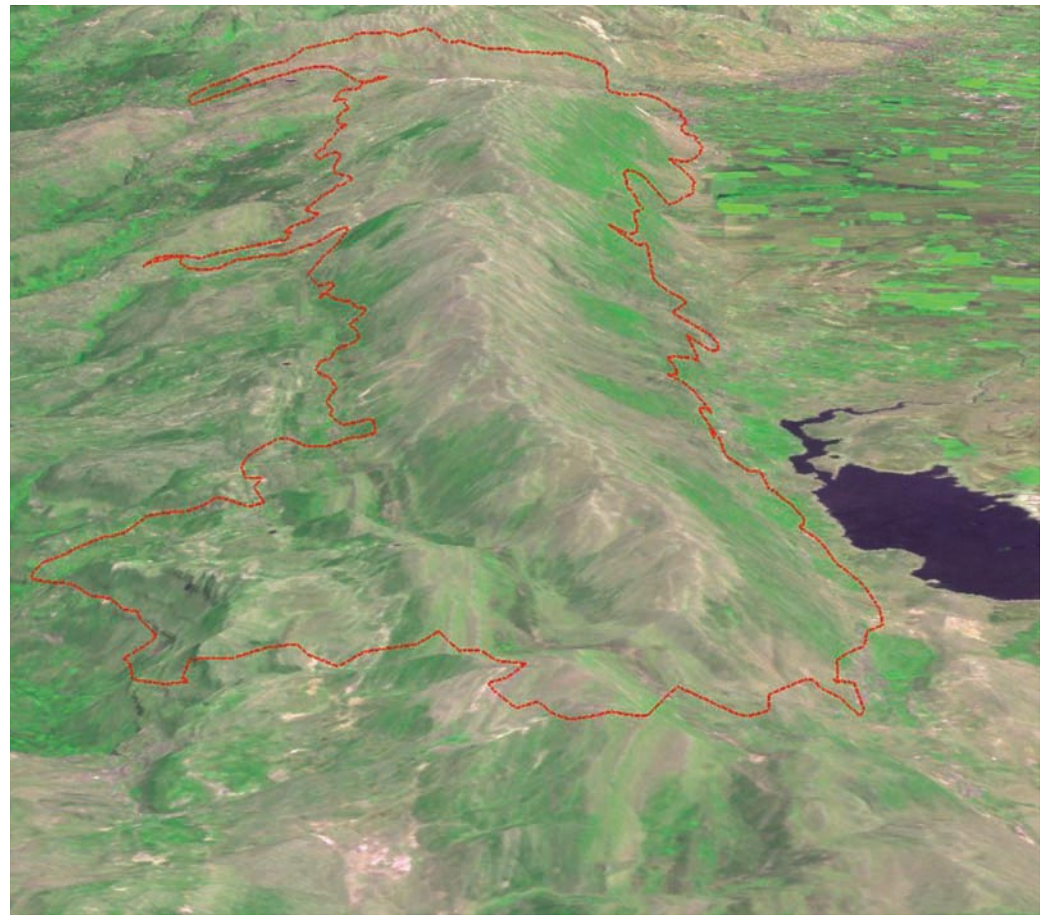


Sat . 16 - IKONOS satellite image for Bentael Natural Reserve for the year 2005

Al-Shouf Cedar Nature Reserve

Al-Shouf Cedar NR, hosting 25% of the remaining cedar forests in Lebanon, encloses the three cedars forests of Maassir Al-Shouf, Al-Barouk and Ain Zhalta-Bmohray. Located on the western slopes of Mount Lebanon chain, the Al-Shouf Cedar NR is the largest NR in Lebanon and extending from Dahr al Baidar in the North to Niha Mountain in the South. Niha represents the natural southern limit of the Lebanon Cedars (Cedrus libani) and is known for the cultural value of the ancient fortress. Al-Shouf Cedar NR is characterized by a great diversity of landscapes, and ecosystems, and harbours 32 species of wild mammals in addition to endemic flora. The reserve has been declared as an Important Bird Area (IBA) by Birdlife International.

Photo 11 - Al-Shouf Cedar Nature Reserve for the year 2005

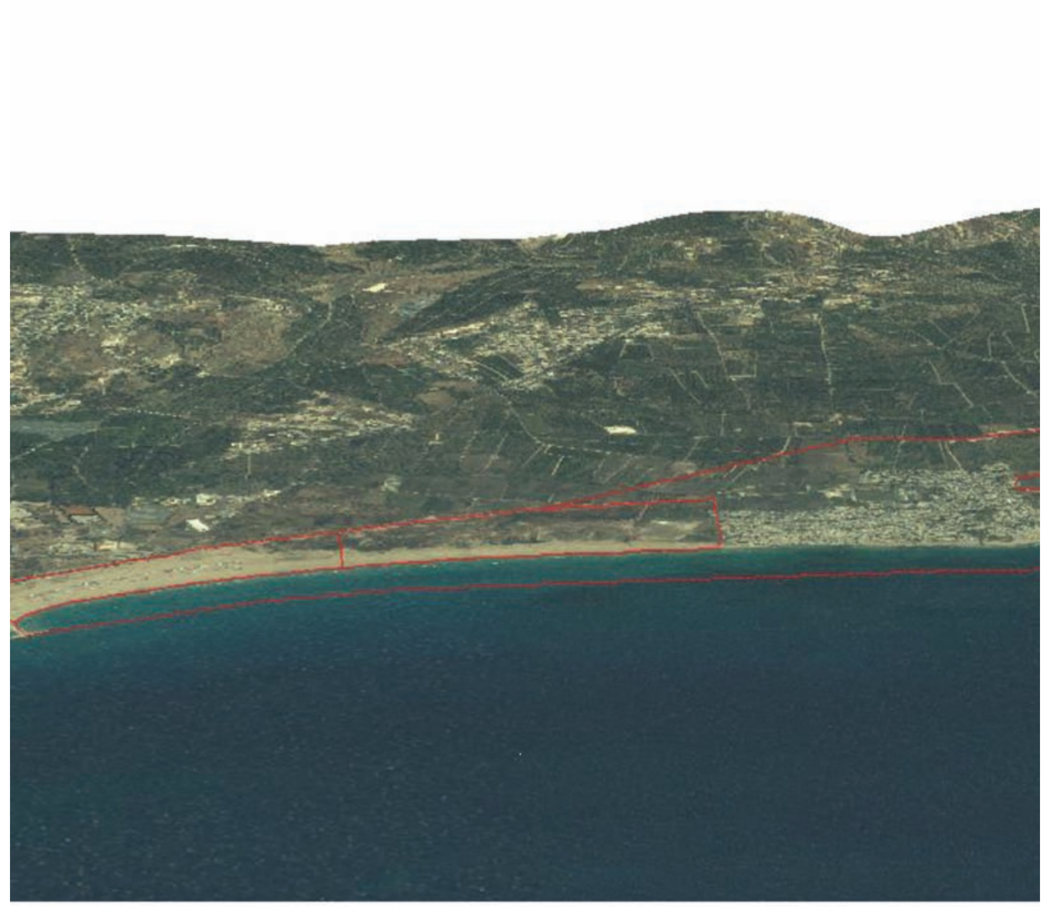


Sat. 17 - IKONOS satellite image for Al-Shouf Cedar Nature Reserve for the year 2005

Tyre Coast Nature Reserve

Located in South Lebanon, over 300 ha of sandy beach, Tyre Coast NR is as well considered as an important wetland and protected as a RAMSAR (Ramsar Convention on Wetlands of International Importance) site.
The site is particularly interesting because it includes the largest sandy beach in Lebanon, contains several fresh water estuaries and has been recognized as a major nesting site for the endangered Loggerhead and Green Turtles in Lebanon.
The Reserve is divided into three sections separated by the Rachidiyeh Palestinian refugee camp.

Photo 12 - Tyre Coast Nature Reserve for the year 2005



Sat. 18 -IKONOS satellite image for Tyre Coast Nature Reserve for the year 2005

Ammiq wetland: A Voluntary reserve

Located in the Western Bekaa, over 280 ha of flooded area, at an altitude of 865 m asl, Ammiq wetlands are the largest remaining freshwater wetlands in Lebanon. Fed by mountain springs, late winter rain and melting snow, the marsh dries out yearly between August and November. Remnant of the swamps, lakes and seasonal marshes which until 1911 covered 90% of the Bekaa Valley, Ammiq wetland is currently used as a major water resource for people locally. It serves for Nature conservation and research as well as a grazing spot for goats and sheep during the dry period of August-November.
Ammiq is considered as a wetland of international Importance (RAMSAR site), an IBA, a Man and Biosphere reserve (MAB) covering more than 28 villages, but mostly Ammiq is a voluntary reserve on which protection is mainly secured by personal initiative of the owners.
Biodiversity on site includes bats and rodents, and carnivores such as Wolves, Foxes, the Otters, Hyenas, Wild cats and Swamp cats, 260 species of birds, reptiles and amphibians, as well as a diverse aquatic plant community that is considered rare in the Middle East region.

Photo 13 - Ammiq wetland

Sat . 19 - IKONOS satellite image for Ammiq wetland for the year 2005

Akkar Donnieh Highlands: at the heart a unique Natural National Park

Acknowledged for its high biodiversity richness, harbouring old vegetation types including the mixed Cedar, Juniper and Pine forests, listed at the top of priority sites designed for protection by the Biodiversity report (UNEP and MoA, 1996) and the National Biodiversity Strategy and Action Plan (1998) and the National Action Program to Combat Desertification (2003), as well as the Lebanese National Master Plan (2004), the Akkar-Donnieh highlands are among of the most deprived regions in Lebanon in terms of lack of basic infrastructure and high unemployment rate.
With more than 500 species of flora and 150 of birds, the area is now being evaluated as a potential Natural National Park. The concerned municipalities of Akkar el Atika, Qobayyat and Fnaideq, have initiated the habitat suitability map and have started to prepare (with MADA association) a common charter for the territory.
Recognized by the MoE, the MoA, the CDR and the DGUP, the area is being examined as a potential Man and the Biosphere reserve as well as an IBA.

Sat . 20 - IKONOS satellite image for Akkar Donnieh Highlands for the year 2005

Photo 14 - Akkar Donnieh Highlands

Section 5

Urbanisation

Major Urban Cities
Tripoli

Tripoli is the city that ranks second in size and population (around 189000 inhabitants). Tripoli is 85 km north to Beirut, located at the international crossroads linking Lebanon to Syria and Turkey. The city was founded in 2000 B.C. as a commercial port, being one of the three main Phoenician cities after Sidon and Arwad. The ancient city is currently located within the Al Mina Island. Through centuries the city was conquered several times, this left many architectural traces. During these different conflicts, the city preserved its traditional urban tissue, Medina, Souks, Hammams, and Mosques.

The city infrastructure is under full rehabilitation; several development projects are being implemented in the area including the extension of the port quay and stockpile capacities, in addition to the creation of a dyke. The Rachid Karami International Fair, a remarkable vast site as seen in the IKONOS image, is located in the eastern part of the Al Mina municipality.

Sat. 21 - Ikonos 80 centimetres resolution satellite image for Tripoli in 2005

Sat . 22 - Ikonos 80 centimetres resolution satellite image for Rachid Karami International fair in 2005

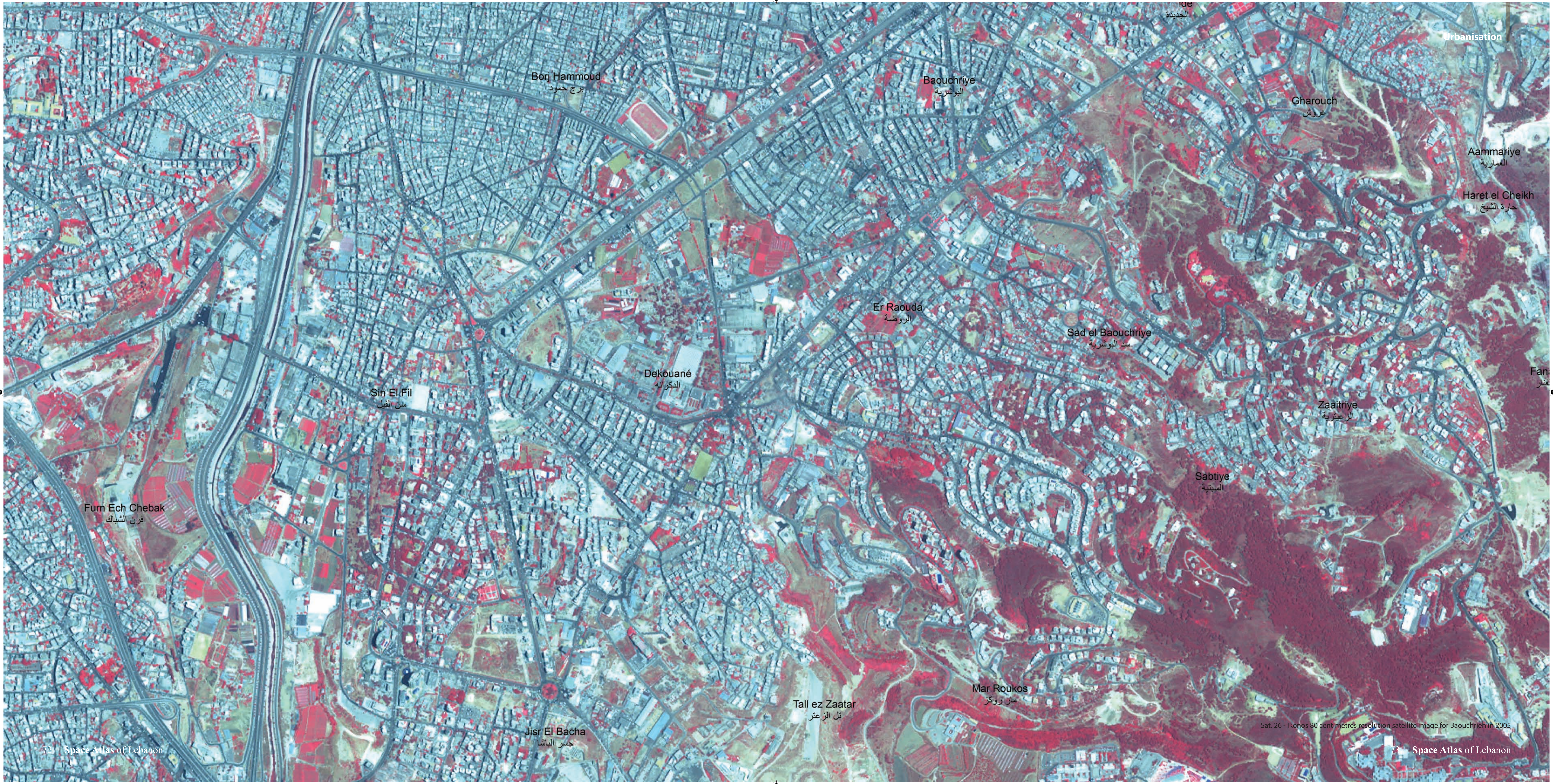
Beirut

Throughout history, Beirut served as a port for Phoenicians and Romans. It witnessed an exponential urban growth during the French mandate period and became the capital during the 20th century. Nowadays, it is populated by 1.3 million people almost 33 % of the total population (CDR, 2003). Greater Beirut city spreads over an area of 468 km² (60 km north – south and 25 km east west) gathering 121 municipalities. The assessment of urban growth requires updated statistics of population estimates. By default, RS techniques allow the assessment of urban expansion of Beirut through the observation of the city morphology. Satellite images are showing that the built up area occupies primarily the coastal plains, this area spreads over crests abandoning valleys and sharp slopes. There is a massive urban expansion of the city from 1950's, following a linear pattern over major transportation networks.

Sat. 23 - Ikonos 80 centimetres resolution satellite image for Beirut in 2005

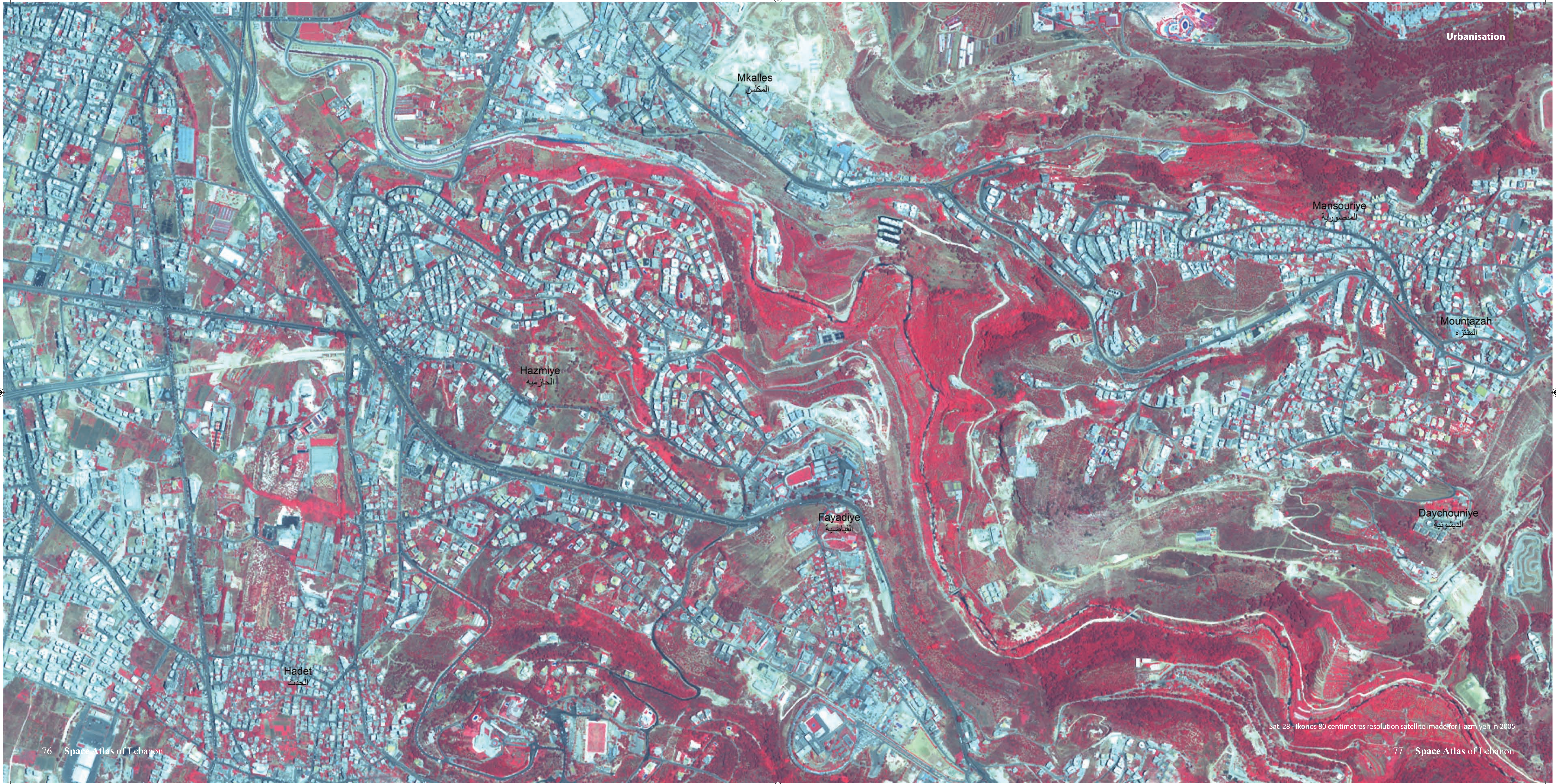
Sat. 24 - Ikonos 80 centimetres resolution satellite image for Zalka in 2005

Sat. 25 - Ikonos 80 centimetres resolution satellite image for Moussaytbe



Sat. 26 - Ikonos 80 centimetres resolution satellite image for Baouchrieh in 2005

Sat. 27 - Ikonos 80 centimetres resolution satellite image for Bir Hassan in 2005



Sat. 28 - Ikonos 80 centimetres resolution satellite image for Hazmiyeh in 2005

Sat. 29 - Ikonos 80 centimetres resolution satellite image for Tahouitet el Ghadir in 2005

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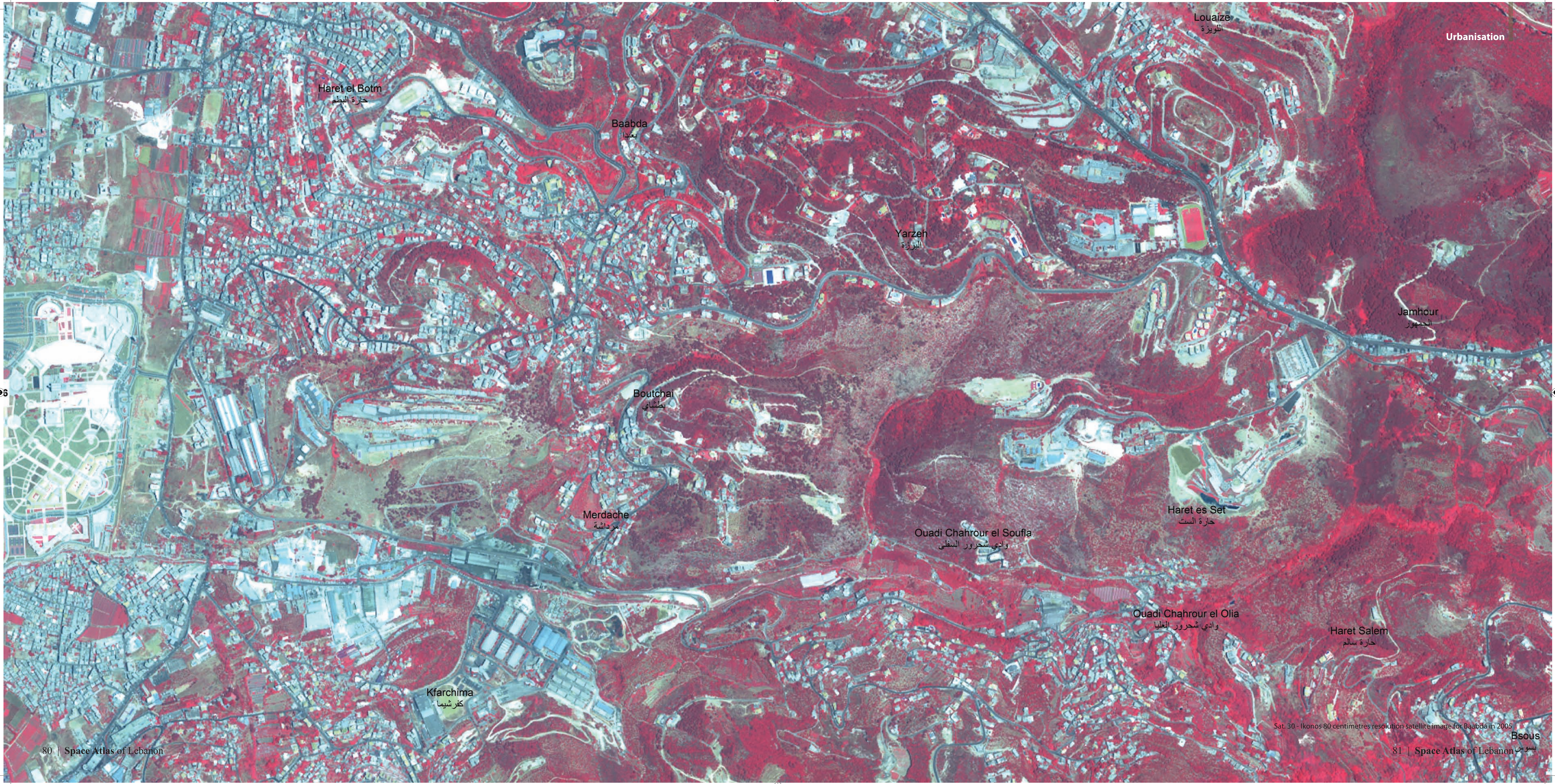
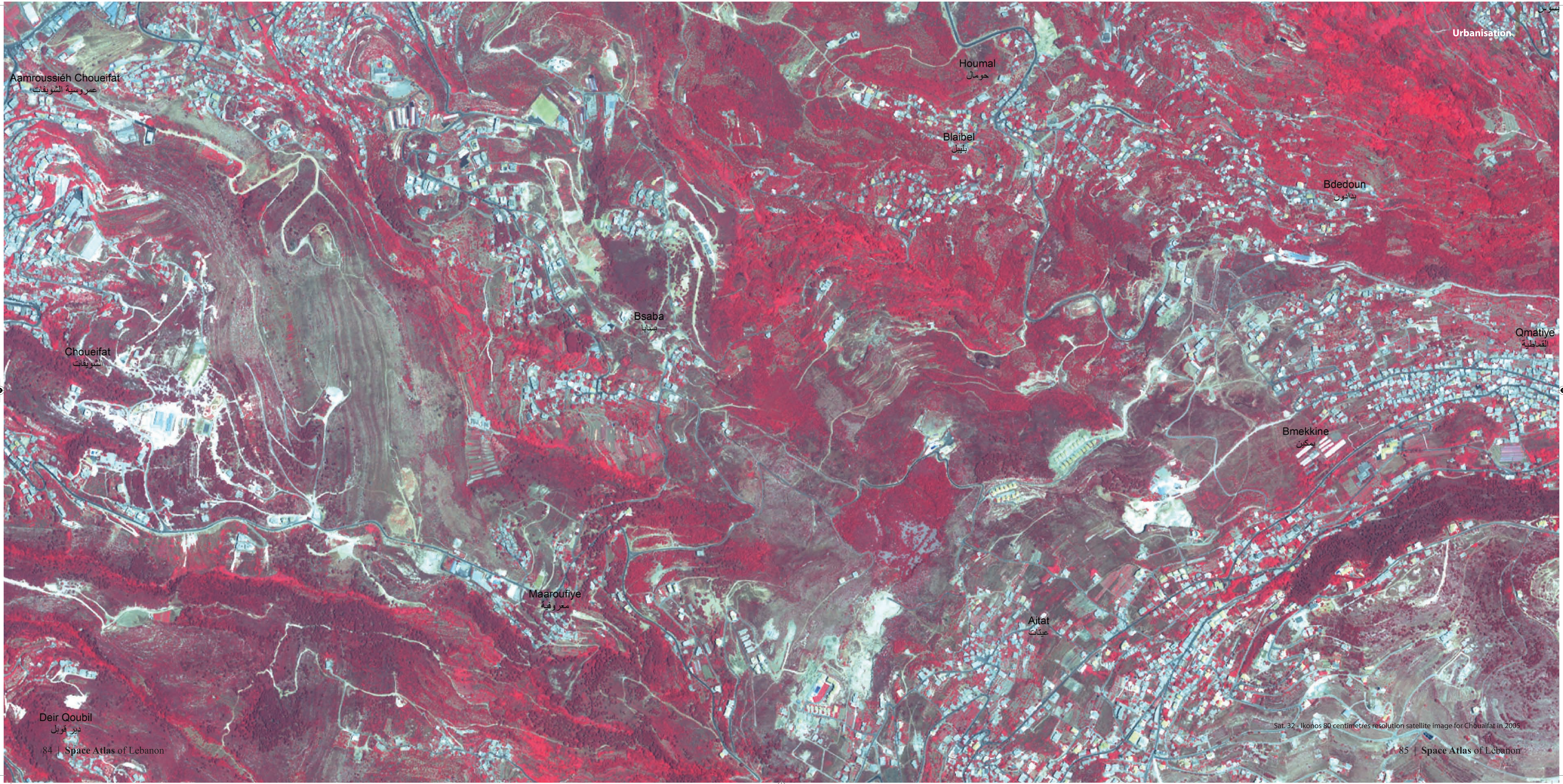


Sat. 30 - Ikonos 80 centimetres resolution satellite image for Baabda in 2005

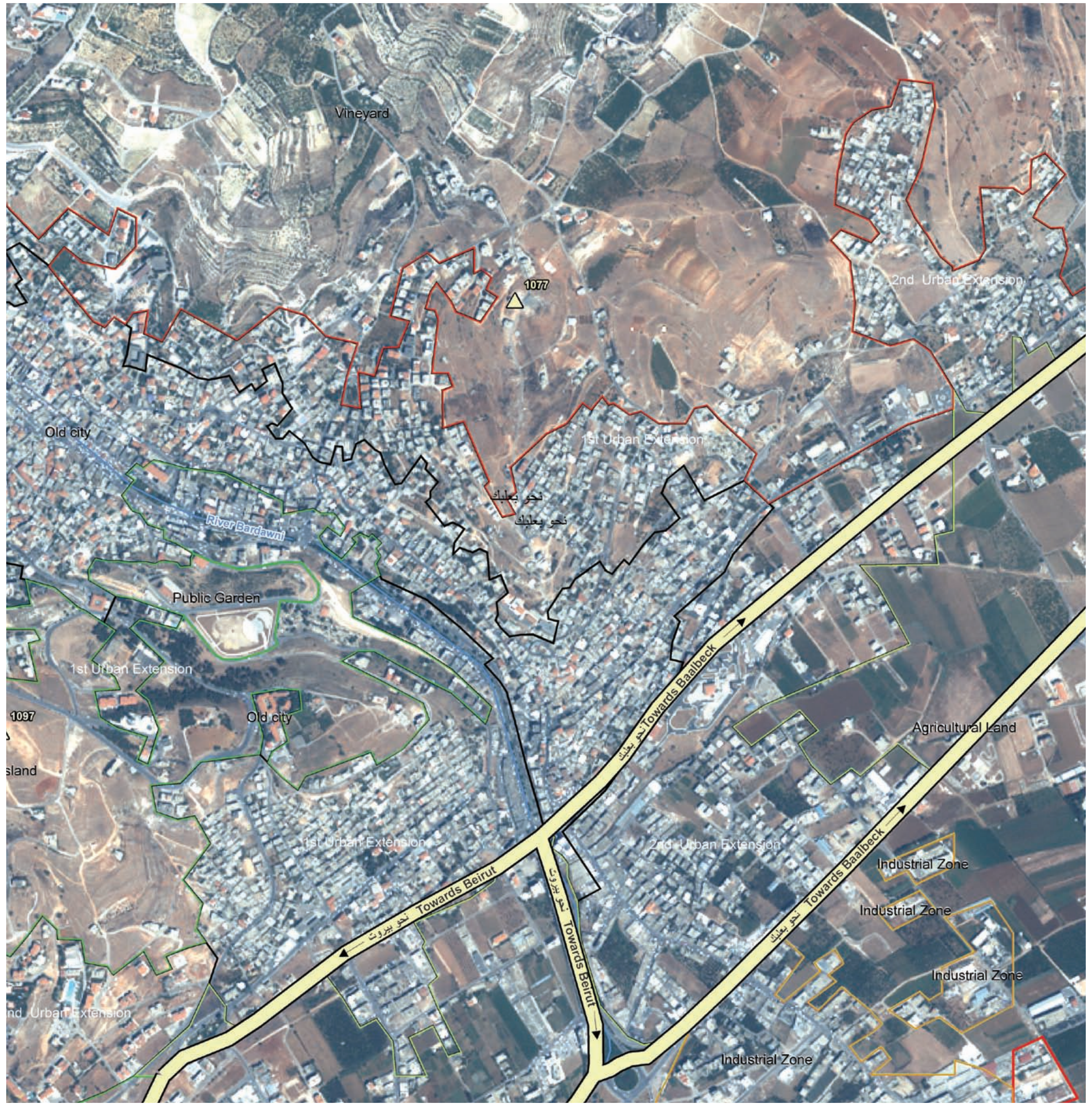
Sat. 31 - Ikonos 80 centimetres resolution satellite image for Beirut Port in 2005



Sat. 32 - Ikonos 80 centimetres resolution satellite image for Chouaifat in 2005

Zahle

Located at an altitude of 950 m, in the centre of the Bekaa valley on the eastern slope of the Mount Lebanon chain. The city is located at the orifice of Wadi Al-Aarayech where different water sources converge from many sources in Mount Lebanon; including the Bardawni River which crosses the old city centre. Founded three centuries ago, the city is considered a centre for agricultural trade, linking the major regional capitals and cities in the region (e.g. Baghdad, Beirut, Damascus, and Mosul). Zahleh is the fifth city of Lebanon with a population of more than 38200 residents. It is the administrative capital of the Bekaa Valley. Its development is linked to the development of the railway in the nineteenth century. Afterward, it became the inner harbour between the Bekaa and Syria. Zahleh has always been an economic centre with a concentration of industrial, commercial, tourism and agriculture activities.



Sat. 33 - Ikonos 80 centimetres resolution satellite image for Zahleh in 2005

Saida

a coastal city at 40 km South of Beirut and 40 km North of Tyre. It ranks third in population on the national scale and first on the scale of South Lebanon (69000 inhabitants). The city spreads over a distance of 7 km along the coast. It knew an important urban expansion tied to a high demographic growth.

The urbanization is arranged along two parallel axes, the North-South axis connecting all coastal cities and the North Eastern-Southern axis. The old centre of the city is located within the littoral promontory whereas the modern extension articulates around the two major parallel axes imposing a rectilinear morphology of the secondary axes.

The city of Saida is considered an industrial and agricultural centre, where fisheries and plantations of citrus and banana are predominant.

Sat. 34 - Ikonos 80 centimetres resolution satellite image for Saida in 2005

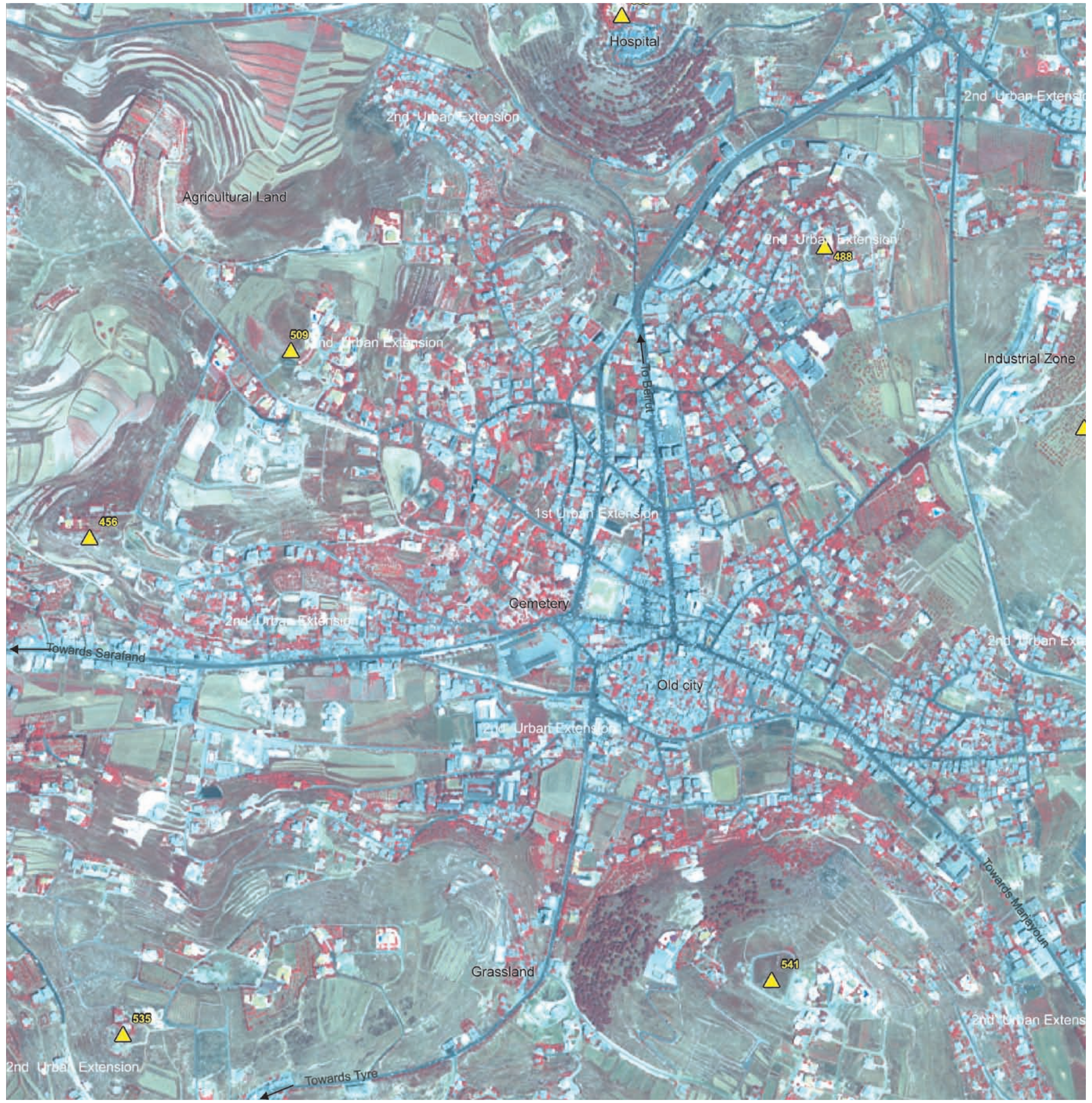
Tyre

The Queen of the Sea, was during ancient times divided into two parts, the Main Land and the Island. The island was built on a small rocky island linked to main land via a 500 m length path. The city has two ports, the southern Egyptian port and the northern Phoenician port. Tyre is the third largest southern city in Lebanon (51000 inhabitants). The city is 40 km south of Saida, 80 km south of Beirut and 35 km from the city of Akka in Palestine to the south. Different rivers pass mainly the northern edge of the city; these are the Litani, Qasmiye and the thermal source of Ain Habrian. Fisheries and agriculture are the main activities practiced within this urban community. Citrus, bananas and greenhouses are clearly visible within the IKONOS image. Tyre is also the most important touristic pole in this region of Lebanon with major archaeological sites, the Roman Hippodrome which is a World Heritage Site since 1984. To the south, the city is bordered by the Tyre Nature reserve which is a RAMSAR site.

Sat. 35 - Ikonos 80 centimetres resolution satellite image for Tyre in 2005

Nabatyeh

Located in the centre of Jabal Amel (historical name of South Lebanon), the city is 22 km south east of Saida and 30 km north east of Tyre. Its foundation dates back to the Nabataean period (second century B.C.)
Nowadays, the city has more than 30000 residents and is in continuous expansion. In South Lebanon, half the population is entirely dependent on agriculture as a source of living that accounts for about 70% of total household income. The topography of the region imposes agriculture in terraces where olive is the main crop. Surrounded by seven hills (Kassayar ez Zaatar, El-Khreibe, Tall Al-Aaskar, As-Saferi, Al-Ouazzani, Tal er-Rouaiss and Tal el Quaiye) and overlooking numerous villages, Nabatiyeh is located in a basin at 410 m altitude. The city forms a crossroad linking the villages of the region following the cardinal axes north-south and east-west. The old town is located at the junction of these two axes, the modern extension is developing in tentacles around the main axes, with a higher urban concentration in the northern part of the old city.



Sat. 36 - Ikonos 80 centimetres resolution satellite image for Nabatiyeh in 2005

Map 16 - Lebanon Infrastructure map

Airports
The first Airport:

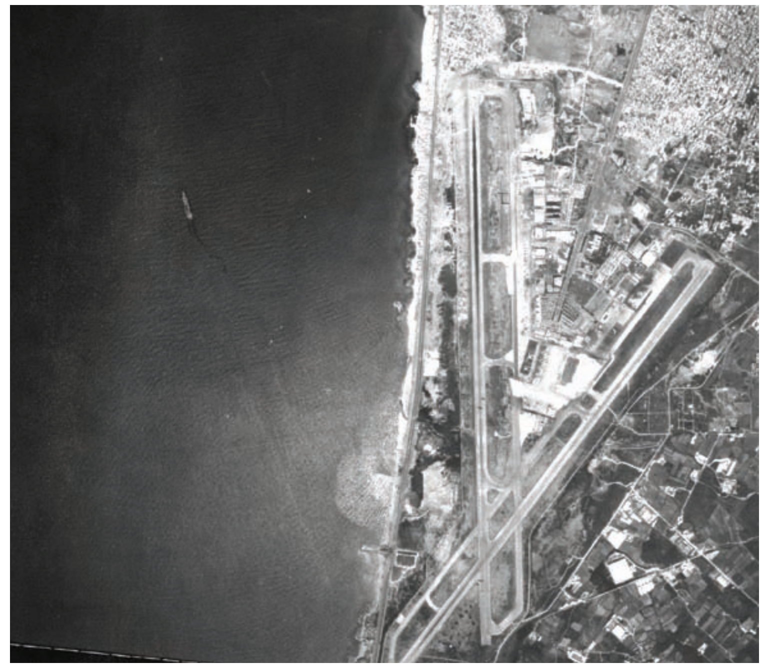
During the Second World War, the aircrafts of the allies were landing at in the small area between the Bridge of Beirut and Al-Dora to the north, before taking hold of Rayak Military Airport, which was constructed by the German Forces in World War One.
Back in 1933, the French had already established a civil airport at "Bir-Hassan" in Beirut, to serve the needs of Lebanon and neighbouring countries. This airport was abandoned later in 1954, when the Beirut International Airport was built.

Beirut Airport

The airport opened on 23 April 1954, replacing the much smaller Bir Hassan Airfield which was located at a short distance to the north. By the time war finally came to an end in 1990, the airport was clearly out-dated and deteriorated. A 10-year reconstruction programme was launched in 1994 to upgrade the airport including the construction of a new terminal and two new runways.
In July 2006, all 3 runways of the airport sustained significant damages from missile strikes by the Israeli Air Force.


Aerial 14 - Bir Hassan Airport, Aerial Photo 1943


Sat. 37 - Corona 1967 Aerial photo for Beirut airport in 1967

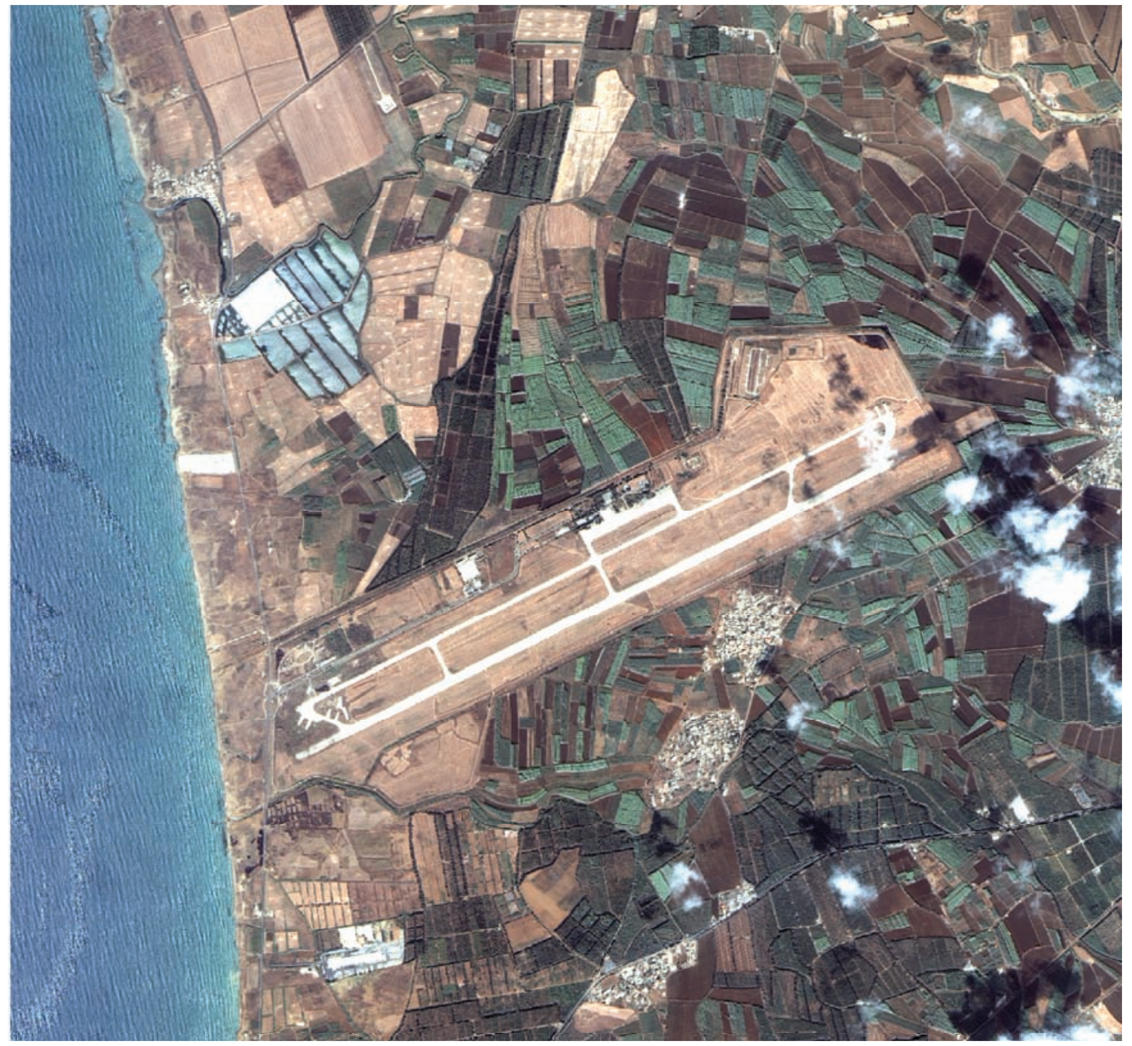

Aerial 15 - Beirut Airport, Aerial Photo 1983


Sat. 38 - Ikonos 80 centimetres resolution satellite image for Beirut airport in 2005

Sat. 39 - Ikonos 80 centimetres resolution satellite image for Riyak airport in 2005

Riyak Airport

Riyak Air Base was constructed and used by the Germans in World War I. After the allies took hold of this base, they enlarged it. During the French Mandate of Lebanon, Rayak Air base was the centre of attraction of all other military units, not only in Lebanon but also in mandated Syria and all the near east. On August 1, 1945, Lebanon took control of its army from the French together with the Battalion of the first airbase (Riyak).



Sat. 40 - Ilkonos 80 centimetres resolution satellite image for Qlaiaat airport in 2005

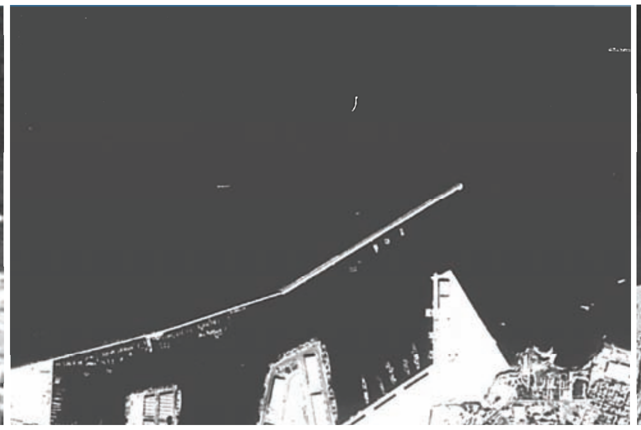
Qlaiaat Airport

In the early 1960's, the air base was a small airport owned by an oil company, IPC (Iraq Petroleum Company), who used small airplanes for transporting its engineers, staff and workers between Lebanon and the Arab countries. In 1966, the Lebanese Army took control of the airport and started expanding and developing its technological capabilities. It later became one of the most modernized air bases in the region. In the 1990's, Middle East Airlines ran flights between this air base and Beirut to serve Tripoli and the surrounding area. On July 13, 2006, the Israeli Air Force bombed the air base.

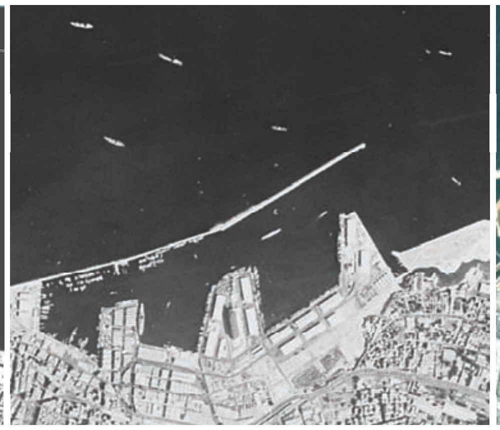
Beirut Port

The capital has a trade port and an international airport for tourists. The opening of the maritime port of Beirut was celebrated in 1894. Since that time many construction works have expanded and developed the port.

Aerial. 16 - Aerial photo for Beirut port in 1943



Sat. 41 - Corona satellite image for Beirut port in 1967



Sat. 42 - Corona satellite image for Beirut port in 1971

Sat. 43 - Ikonos 80 centimetres resolution satellite for Beirut port in 2005

Sat. 44 - Ikonos 80 centimetres resolution satellite for Tripoli port in 2005

Sat. 45 - Ikonos 80 centimetres resolution satellite for Saida port in 2005

The Port of Tripoli is the 2nd major port in Lebanon. The port covers an approximate area of 3 Km^2 (1.2 sq mi), with a water area of 2.2 Km^2 (0.85 sq. mi), and the land area composing of 320,000 m^2 (3,400,000 sq. ft), and a 420,000 m^2 (4,500,000 sq ft) dump area adjacent to the current port, reserved for the future Container Terminal and Free Zone. The Port of Tripoli was "re-founded" in 1959 and a modest free zone was later added in 1971.

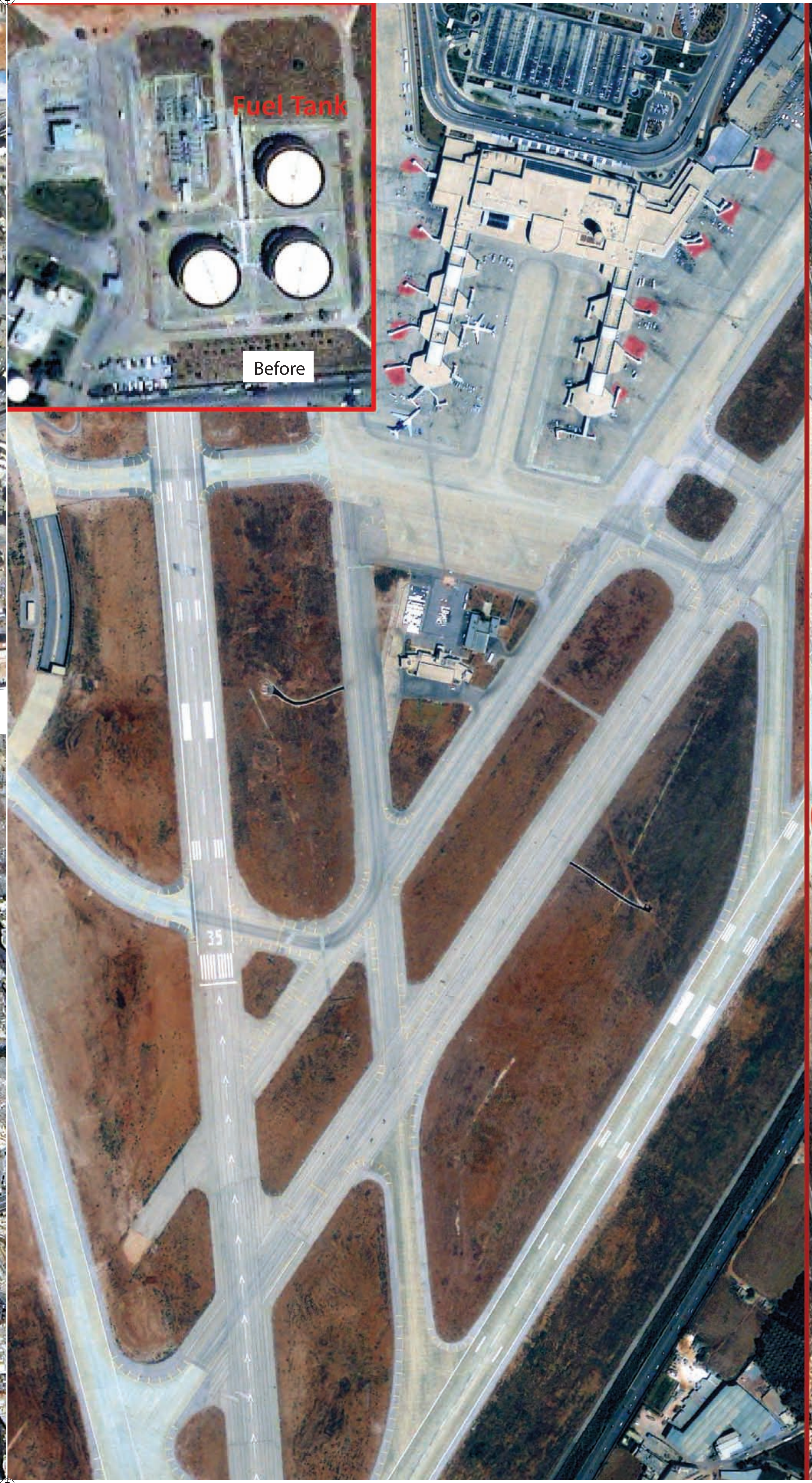
Sat. 46 - Quickbird satellite image for South Beirut neighbourhood before and after the 2006 July war

2006 War Damage in Lebanon

Starting July 12^{th} 2006, the Israeli army attacked and bombarded for 33 days the main roads and infrastructure of Lebanon leading to very serious damages estimated by the Lebanese authorities, to some U.S.$ 3.6 billion as direct property damage, including nearly U.S.$ 1.2 billion Dollars for infrastructure and industrial facilities and US$ 2.4 billion for homes and businesses.

While housing remains by far the most affected by the Israeli bombardment, with an estimated loss of U.S.$ 1.7 billion, it is followed by the industrial and commercial sectors which have been allocated nearly U.S.$ 400 million, and agriculture and irrigation facilities whose losses ranged between U.S.$ 300 and 400 million. The production of maps locating the bombarded areas provided a first insight into the extent of damage and permitted the establishment of reconstruction priorities.

A set of full coverage of images from the Russian satellite KVR 1000 (2 m resolution) was purchased in order to finely assess the damage of the July 2006 by comparing high resolution satellite images from before and after the war.



Sat. 47 - Quickbird satellite images for the fuel tank before and after 2006 July War


Sat. 48 - Industrial zone of Taanayel
District: Zahleh
Governorate: Bekaa


Sat. 49 - Industrial zone of Dbayeh
District: Al-Matn
Governorate: Mount Lebanon


Sat. 50 - Industrial zone of Zahleh
District: Zahleh
Governorate: Bekaa


Sat. 51 - Industrial zone of Mazraat Yachouaa
District: Al-Matn
Governorate: Mount Lebanon


Sat. 52 - Industrial zone of Chekka
District: Batroun
Governorate: North Lebanon


Sat. 53 - Industrial zone of Aley
District: Aley
Governorate: Mount Lebanon


Sat. 54 - Industrial zone of Mkalles
District: Al-Matn
Governorate: Mount Lebanon


Sat. 55 - Industrial zone of Fanar
District: Al-Matn
Governorate: Mount Lebanon


Sat. 56 - Industrial zone of Bauchrieh
District: Al-Matn
Governorate: Mount Lebanon

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Section

6

Risk Studies

Sat. 73 Jieh Power Plant

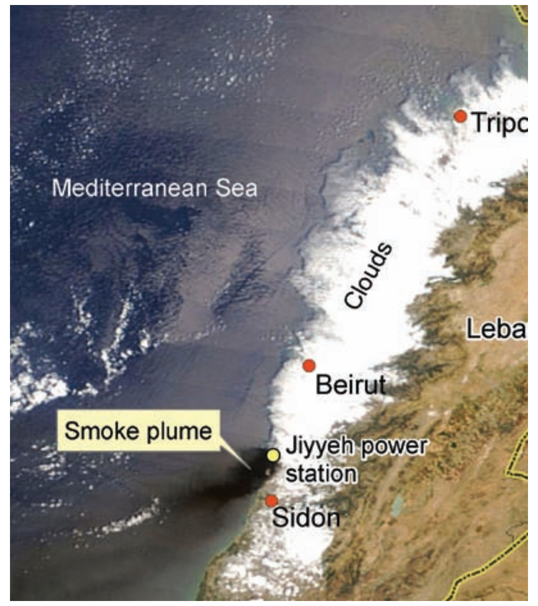
Oil spill Follow up using Spatial Technology

The fuel oil spilled into the sea following an Israeli attack on the Jiyyeh Power Plant affected about 140 km of the Lebanese coast situated to the north of the spill site. Its impact on the marine ecosystem was obviously seen. The sandy beaches and vermetid terraces were the most polluted part of the coast where massive mortality of Gastropods, Crustaceans, Echinoderms, Fish and Macroscopic Algae was recorded, especially in the moderately and heavily polluted sites.

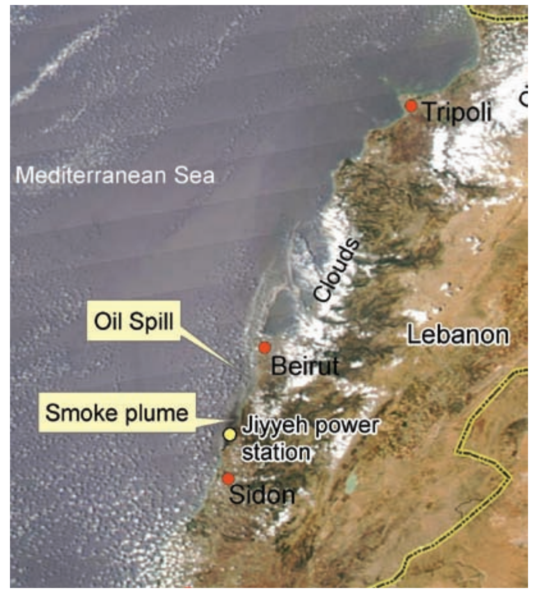
Hydrobiological components of water suffered and showed notable modifications one month after the oil spill; the nitrate and nitrite ion levels increased in most the analysed sites along with a disturbance of the phytoplanktonic population expressed by the destruction of cell organelles and the disappearance of chloroplast in most of them. This situation seems to be returning to normal since October 2006.

The meiobenthic fauna has been also affected by the oil spill, especially on the sandy beaches exposed to wave movement and constantly polluted by fuel oil. At 10 meters depth, the meiobenthic community seemed not to be affected.

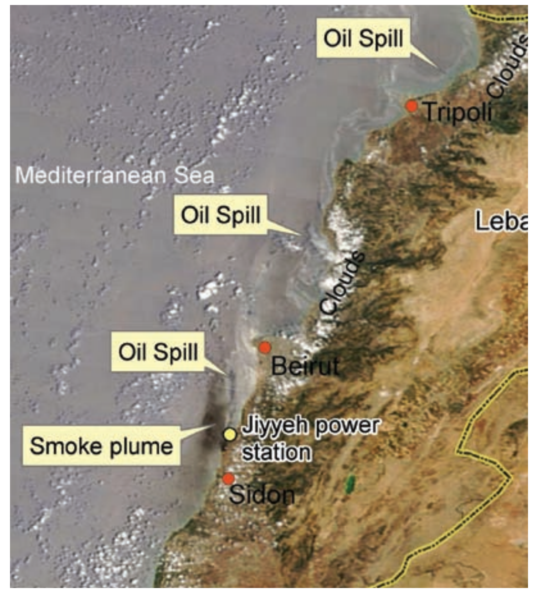
Sat. 57 - TERRA / ASTER satellite images for the Lebanese coast 2006



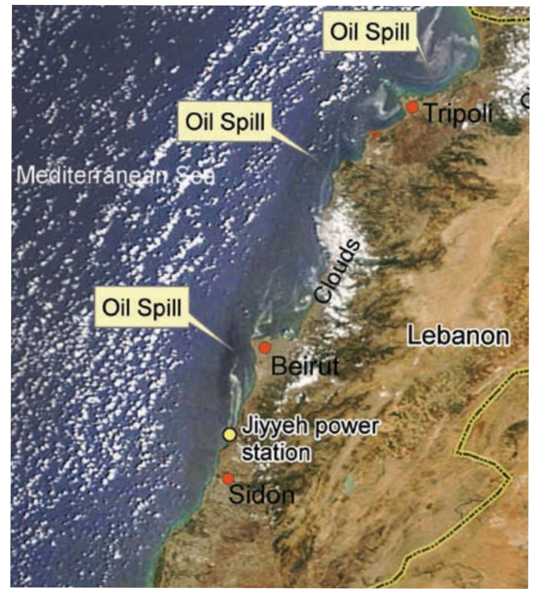
Sat. 58 - TERRA / ASTER satellite images for the oil spill to the sea on the 16th July 2006



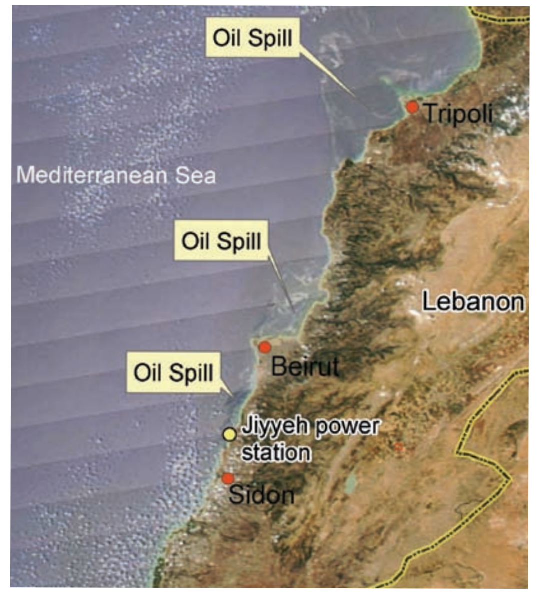
Sat. 59 - TERRA / ASTER satellite images for the oil spill to the sea on the 19th July 2006



Sat. 60 - TERRA / ASTER satellite images for the oil spill to the sea on the 23rd July 2006

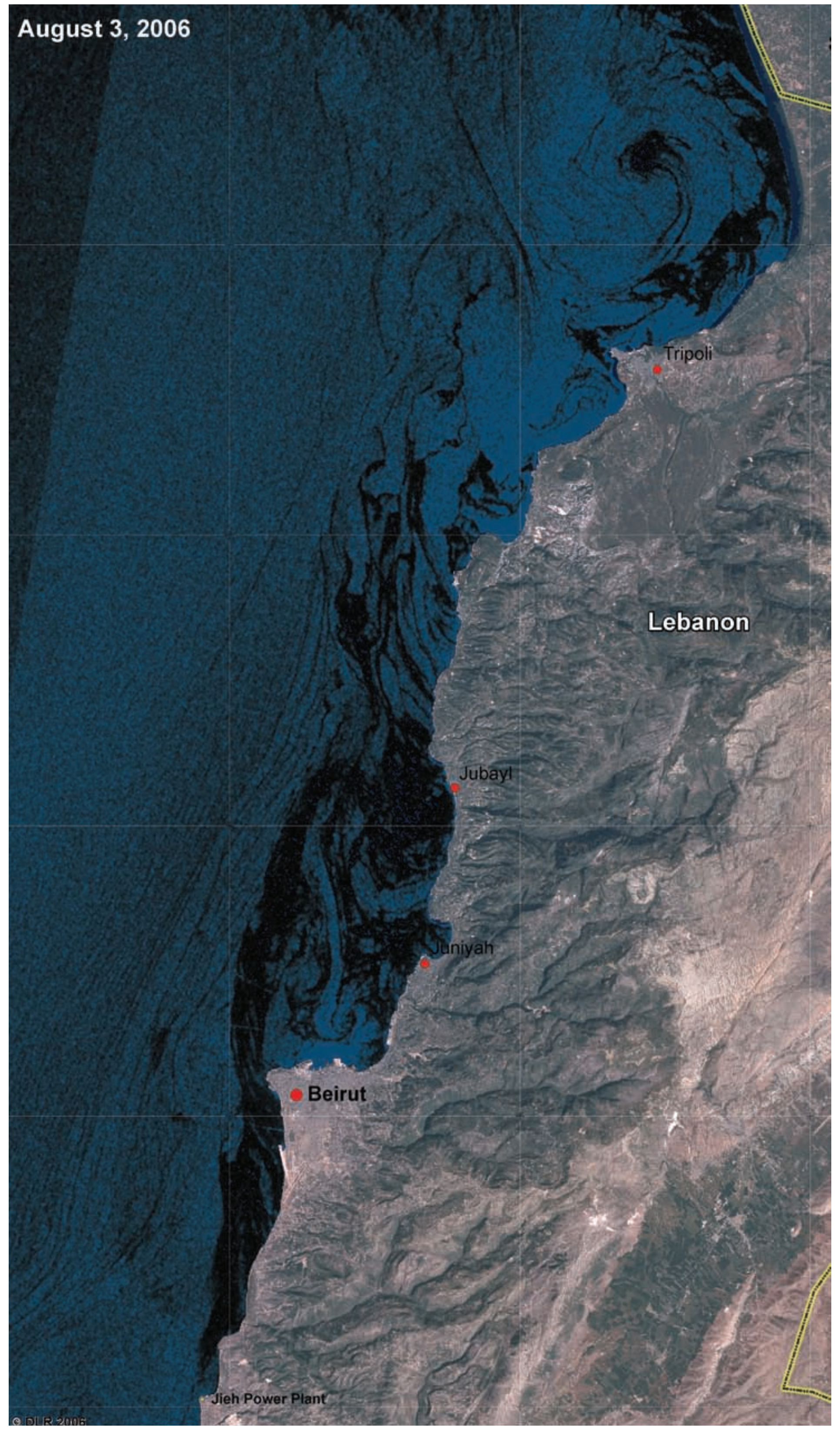


Sat. 61 - TERRA / ASTER satellite images for the oil spill to the sea on the 1st august 2006

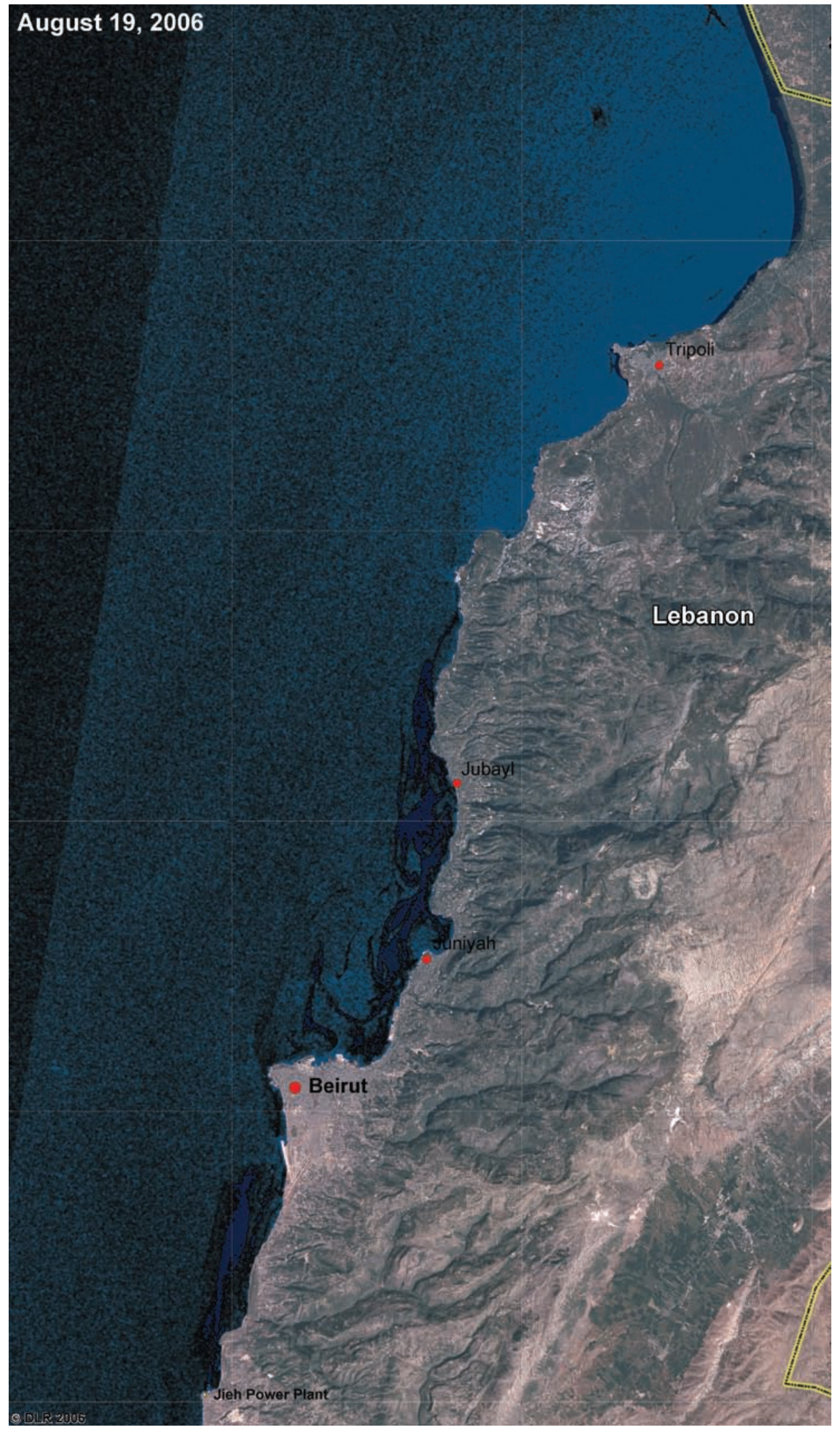


Sat. 62 - TERRA / ASTER satellite images for the oil spill to the sea on the 4th august 2006

The maps bellow show below a comparison of the oil slicks between August 3 and August 19, 2006 based on radar imagery from the ENVISAT ASAR sensor. Due to the different backscatter behaviour of the ocean surface, the oil slicks can be identified as black patches. The radar information was combined with optical Landsat data to ease image interpretation.



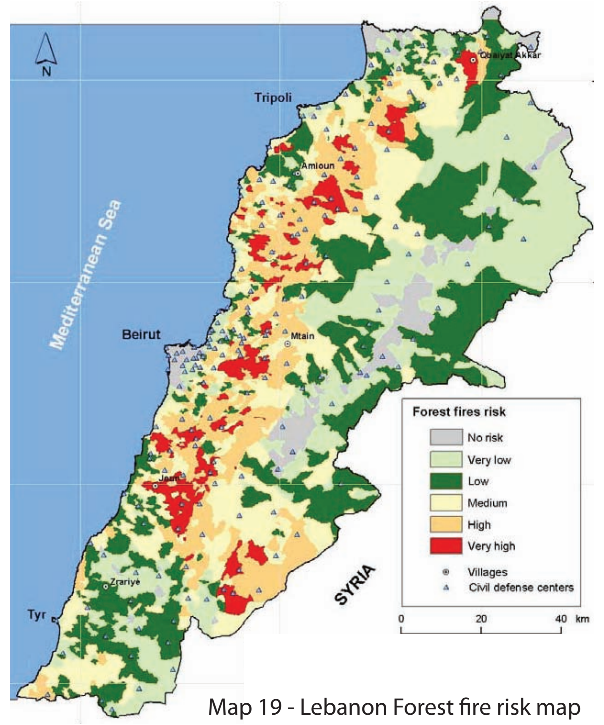
Map 17 - Envisat Asar map for the oil slicks in Lebanon on August 3, 2006



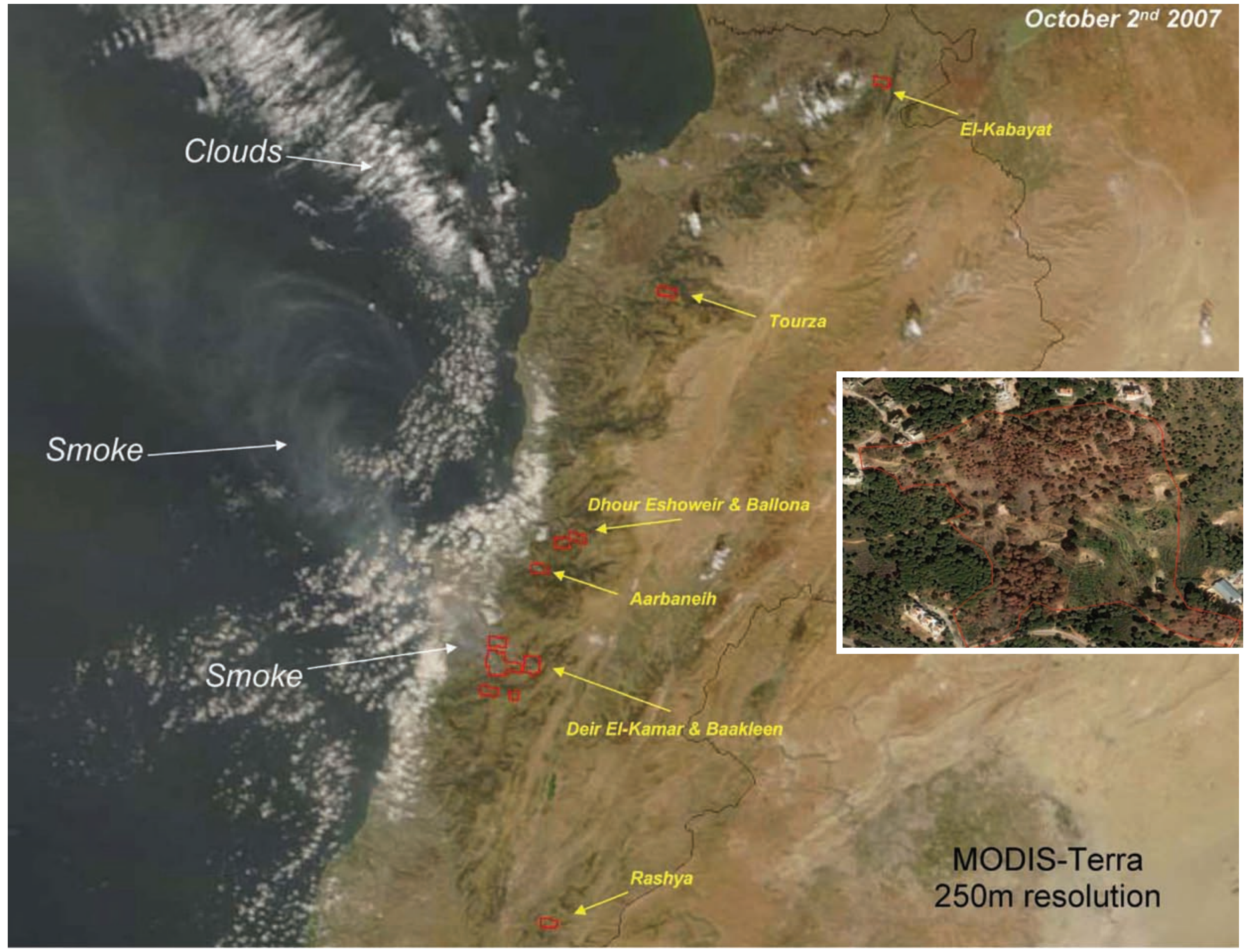
Map 18 - Envisat Asar map for the oil slicks in Lebanon on August 19, 2006

Forest fires

More than 35% of the initial forest cover in Lebanon has been deteriorated during the last 40 years leading to a green cover reduction from 12% (1973) to less than 7% of the Lebanese territory nowadays. The map hereinafter represet the frest fore risk map for the year 2006 done by the CNRS-CRS for the entite country, whle the Modis-terr (250m resolution) image shows smoke and clouds directly after the fire occure.



Map 19 - Lebanon Forest fire risk map



Sat. 63 - MODIS-Terra 250m resolution for Lebanon in October 2nd 2007

Detection of sea water pollution along the Lebanese coastal line using the thermal infrared band of Landsat-7 ETM+

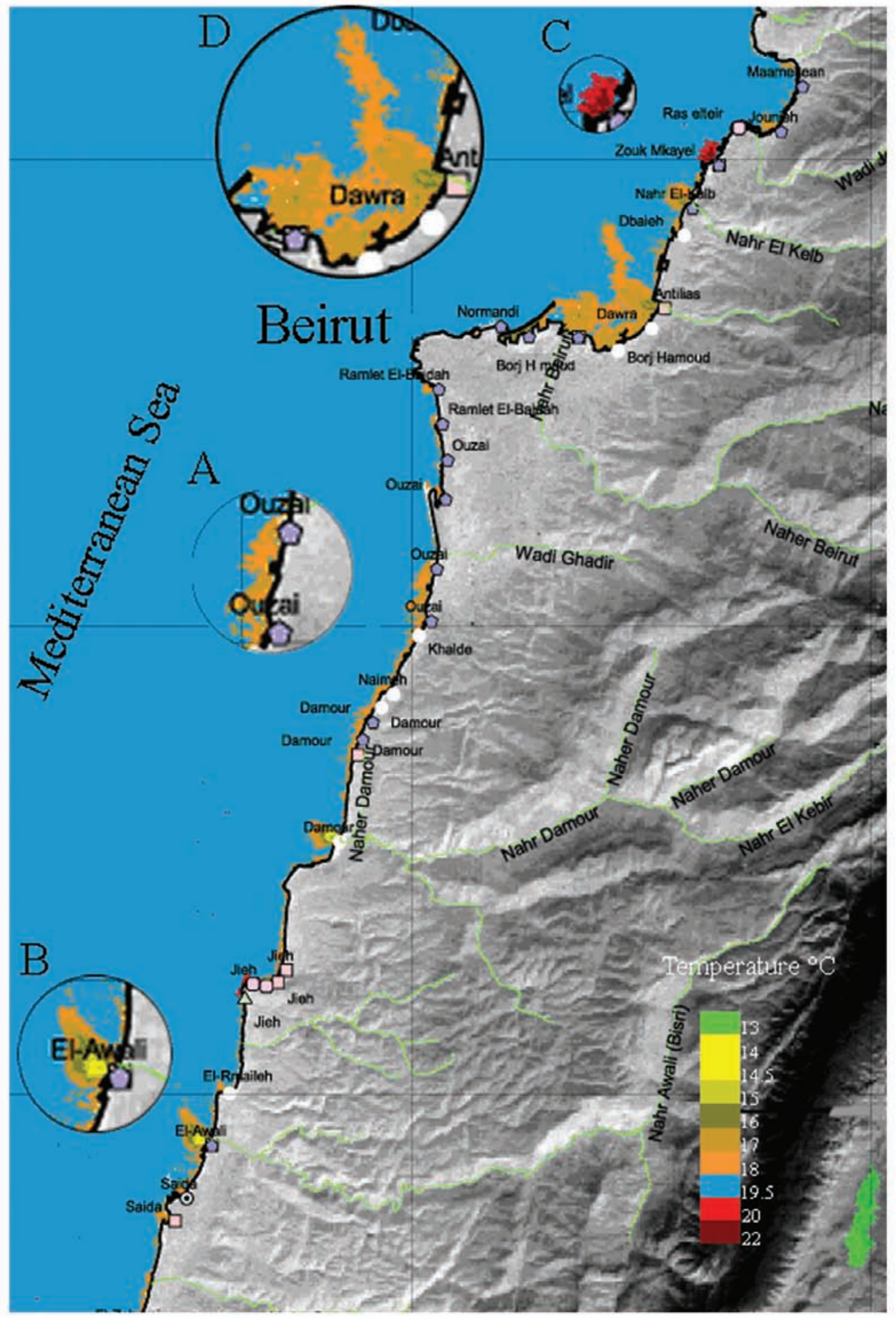
The marine environment in Lebanon is heavily affected by land-based pollution. This problem mostly concerns areas with dense urban activities. While threatening the marine ecosystem, it also affects, as a consequence, the human populations. Along the 225 km coastal line, 75 permanent or temporary watercourses discharge polluted water and wastewater into the sea. With the addition of numerous sewage outlets and oil spills. These pollution inputs are categorized under four major classes:

1) Wastewater inflows.
2) River-transported sediments and debris.
3) Thermal inflows.
4) Chemical and oily fluids.

The true areal extent of this pollution is not well identified yet, which requests a comprehensive and continuous observation and monitoring of the coastal waters. The thermal bands of satellite images of Landsat-7 ETM+, can be successfully utilized for this purpose. The principle of this identification is based on thermal differentiation between seawater and polluted water temperatures. This thermal mapping has identified 49 major sources of pollution in the Lebanese marine environment, the nature of which has been checked in the field. Most of them are related to uncontrolled human activities, such as sewage outlets, refineries and factories. These results should provide decision-makers with a sound base for developing and implementing the necessary mitigation policies.

Pollution aspects along the Lebanese shoreline.

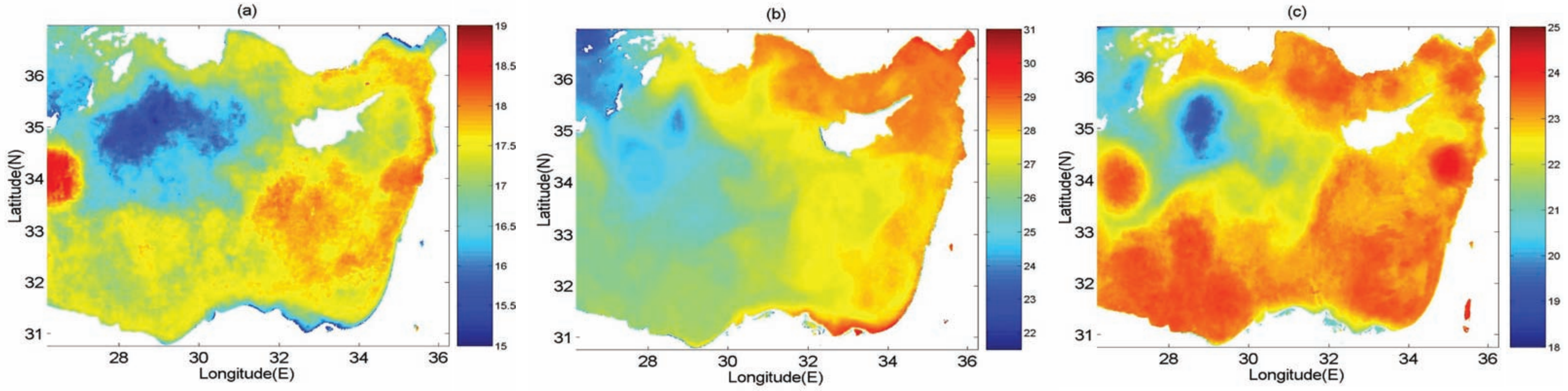
A) Water outfalls.
B) Transported sediments and debris along rivers.
C) Warm waters from an electric power station.
D) Chemical and petroleum fluids mixed with stream waters.



Sat. 64 - Landsat-7 ETM+ image - Detection of seawater pollution along the Lebanese coast

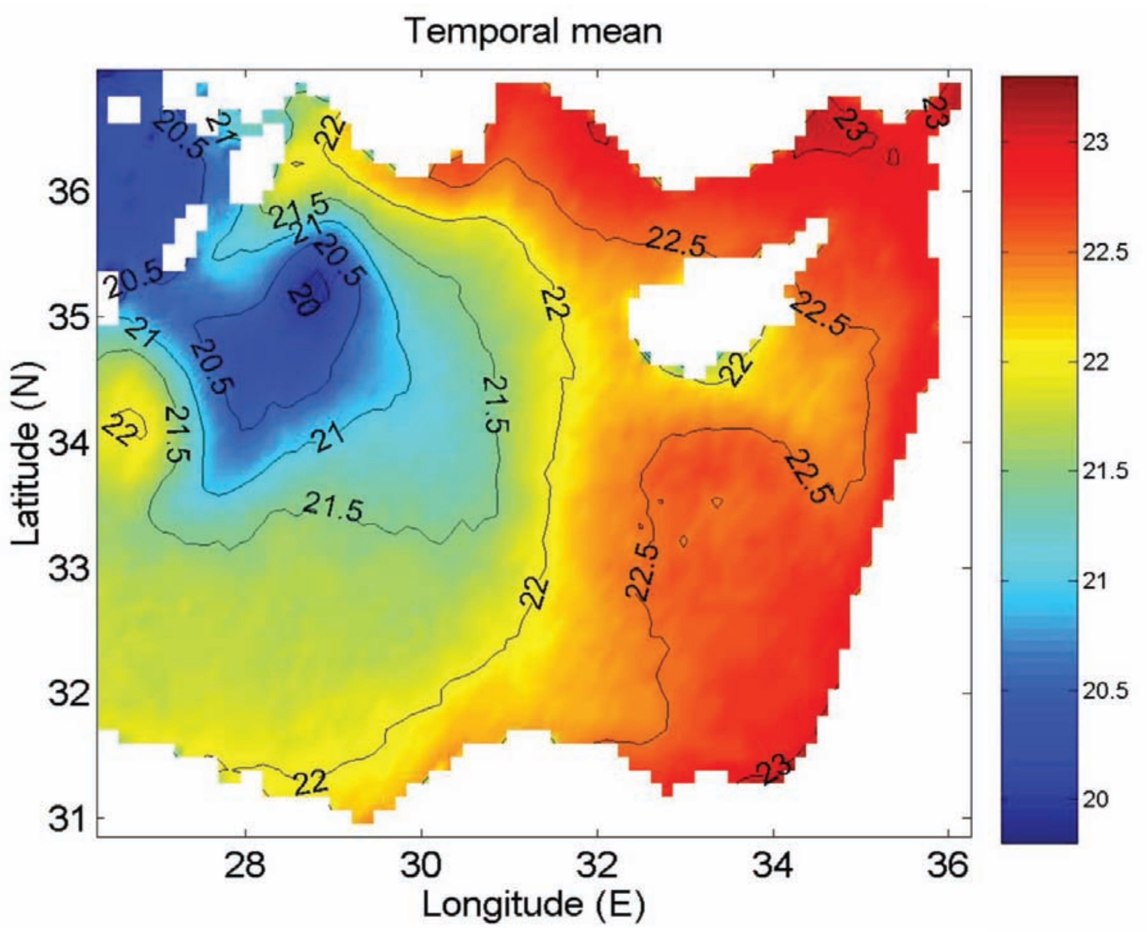
Sea Surface Temperature

The continuous set of satellite measurements taken over the Mediterranean is that of the sea surface temperature derived from the Advanced Very High Resolution Radiometer (AVHRR) of the National Oceanic and Atmospheric Administration (NOAA) satellites supplemented more recently by the Along-Track Scanning Radiometer (ATSR) of ERS-1/2. Accuracies lie in the range of 0.3-0.5 ºC and spatial resolution is about 1km.
The most striking feature of the AVHRR SST images is the intricate pattern apparent in the Mediterranean Sea temperature. The entire sea is covered by eddy structures ranging in size from less than 10 km to nearly 100 km. In November 2000 (Figure 1), a warm pool has formed off the Lebanese coast, which is, probably, due to a clockwise gyre activity.



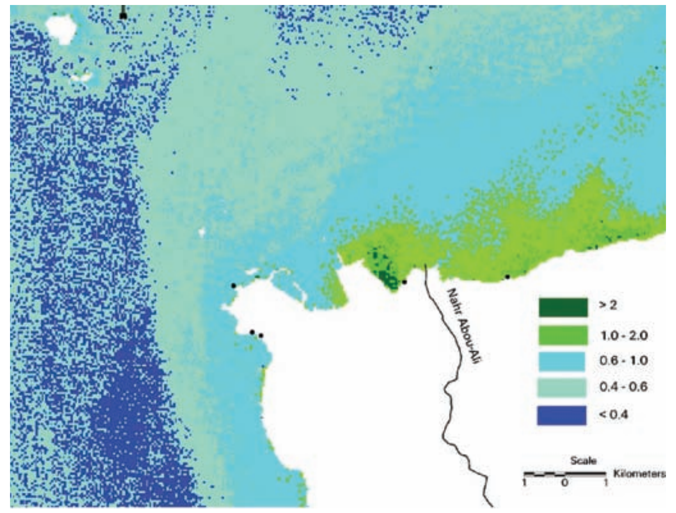
Sat. 65 - Monthly mean AVHRR Sea surface temperature images of the Levantine Basin for February 2000(a), August 2000 (b) and November (c)

Sat. 66 - Temporal mean Sea Surface Temperature field for the Levantine Basin compiled from 36 AVHRR images from January 1998 to December 2000.

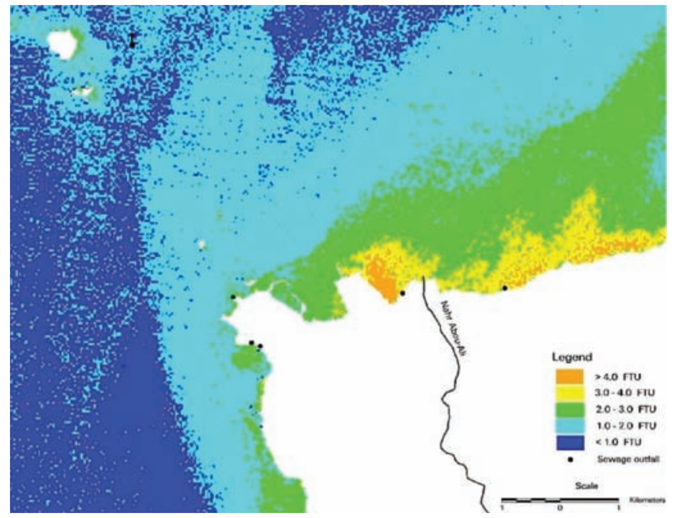


Ocean colour radiometry

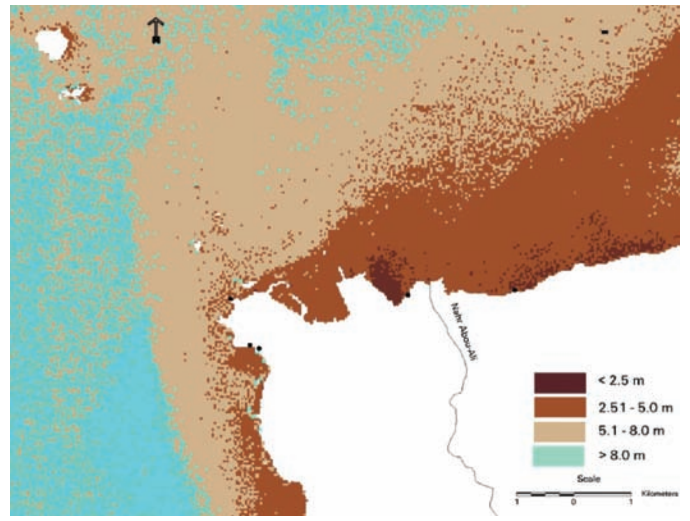
Ocean colour radiometry has been successfully applied for the retrieval of phytoplankton biomass indices, such as chlorophyll-A concentration, and other water quality parameters (turbidity, Secchi disk depth, etc.). Sensors originally designed for land observations, like Landsat's thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+), have proven to be very useful for assessing coastal and Estuarine systems primarily because of their higher spatial resolution (30 m, or half that in panchromatic mode). Water quality in the coastal area of Tripoli (Lebanon) was assessed using Landsat 7 ETM+ data (Kabbara et al., 2008). Significant pigment concentrations are seen along the coast. Localized areas of high production are due to pollution from human activities.



Map 20 - Chlorophyll-a map of the Tripoli coastal area

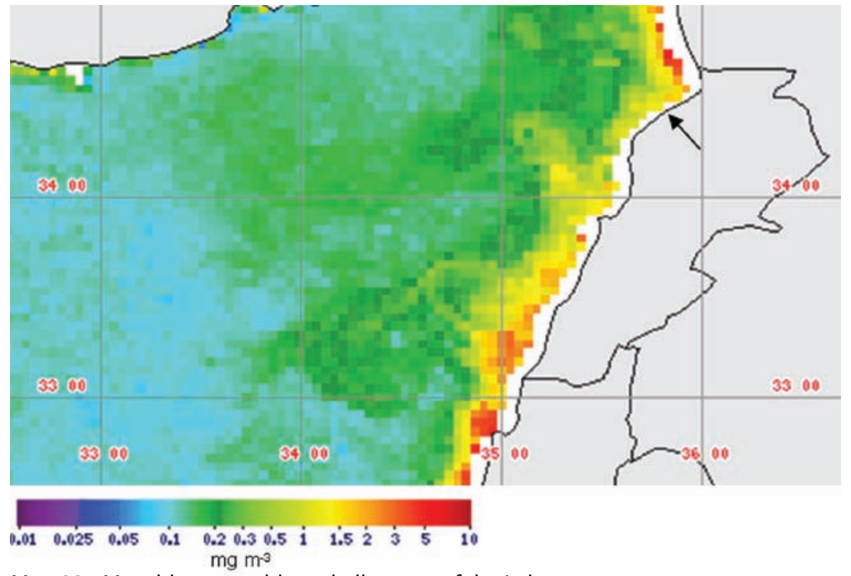


Map 21 - Turbidity map of the Tripoli coastal area



Map 22 - Secchi disk depth map of the Tripoli coastal area

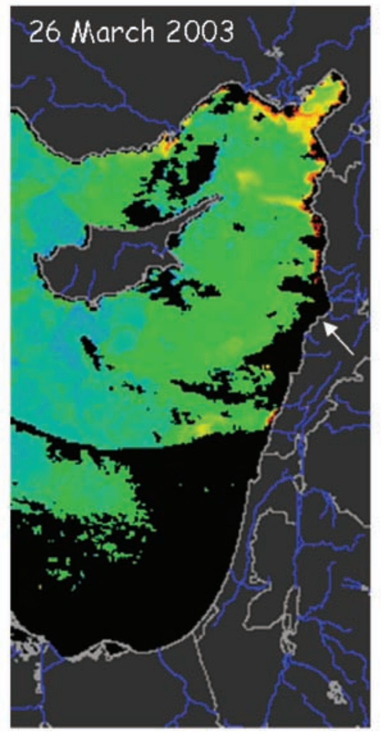
Chlorophyll-like pigments in the Lebanese coastal area as derived from the currently operational orbital sensor Sea-viewing Wide Field-of-view Sensor (SeaWiFS, since 1997).
The comparison of the chlorophyll-A map with the concurrent SeaWiFS derived imagery covering the eastern most part of the Levantine Basin shows that in both cases offshore waters present concentrations up to approximately 0.4 mg m^{-3} (except for a number of large-scale coastal plumes, where the concentration can be twice that value). Inshore waters in the images of Figure 6 present concentrations around or above 1.0 mg m^{-3}.



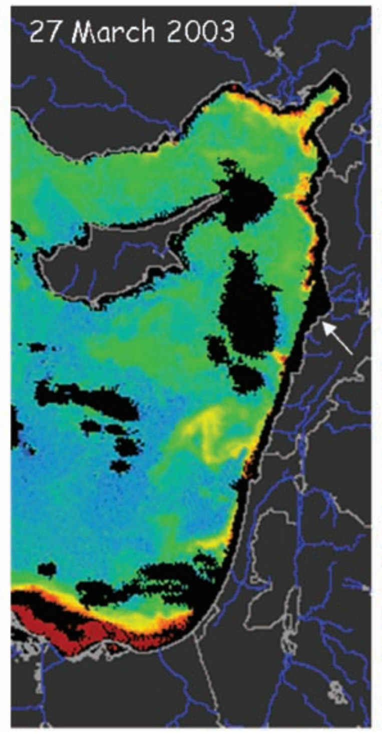
Map 23 - Monthly mean chlorophyll-a map of the Lebanese waters

Monthly mean chlorophyll-a map of Lebanese waters. The black arrow indicates the area of Tripoli. From SeaWiFS data, at 5 km resolution; March 2003 (from Kabbara et al., 2008).

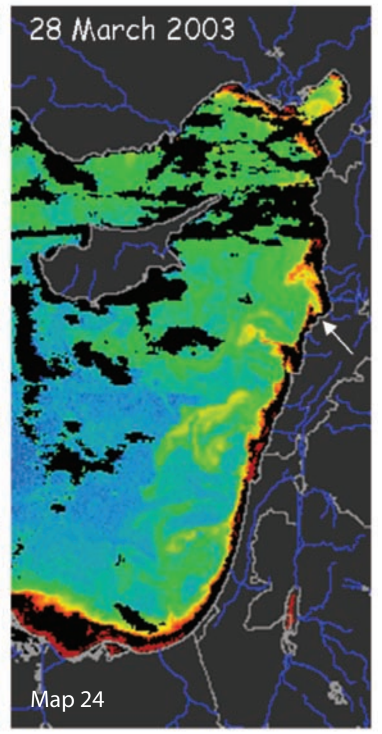
Chlorophyll-a maps of the eastern Mediterranean Sea. Black pixels represent clouds, points contaminated by noise or near-coastal areas. The white arrows indicate the area of Tripoli. From SeaWiFS data, at 2 km resolution; 26, 27 and 28 March



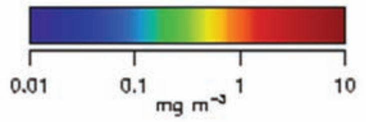
Map 24 - Chlorophyll-a maps of the Eastern Mediterranean Sea for 26 March 2003



Map 25 - Chlorophyll-a maps of the Eastern Mediterranean Sea for 27 March 2003

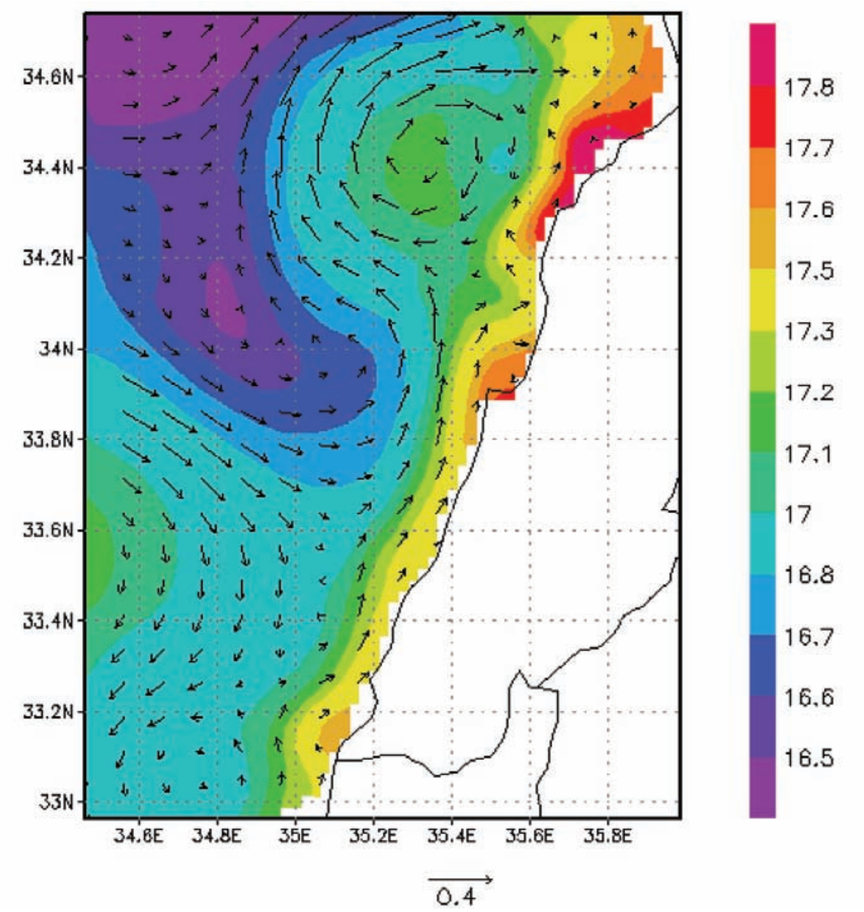


Map 26 - Chlorophyll-a maps of the Eastern Mediterranean Sea for 28 March 2003

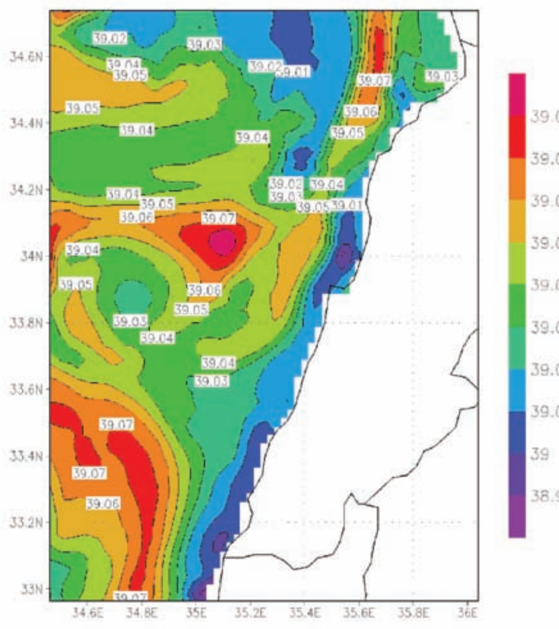


Data assimilation and the use of satellite data

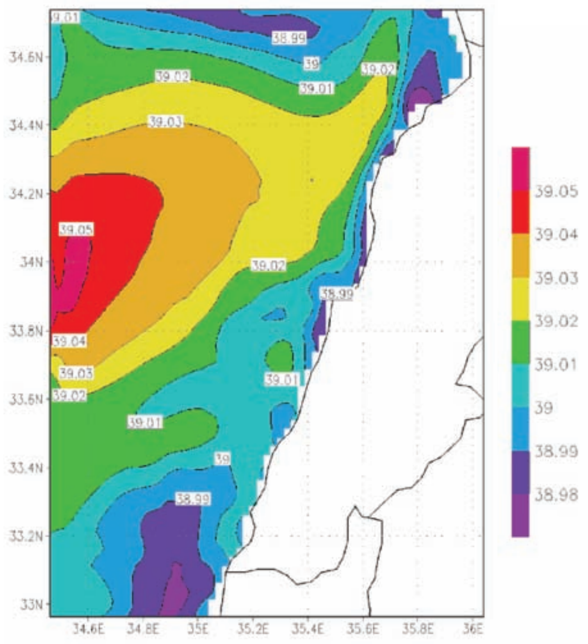
Satellite data represent by far the largest volume of data used in the European Centre for Medium- Range Weather Forecasts (ECMWF) data assimilation system.
Monthly means of wind stress, heat and water fluxes on the sea surface were calculated from ECMWF 6-hourly Re-Analysis (ERA) dataset covering the period 1079-1993 and used as surface forcing for the hydrodynamic model: The Lebanese Shelf Model (Kabbara et al. 2006).



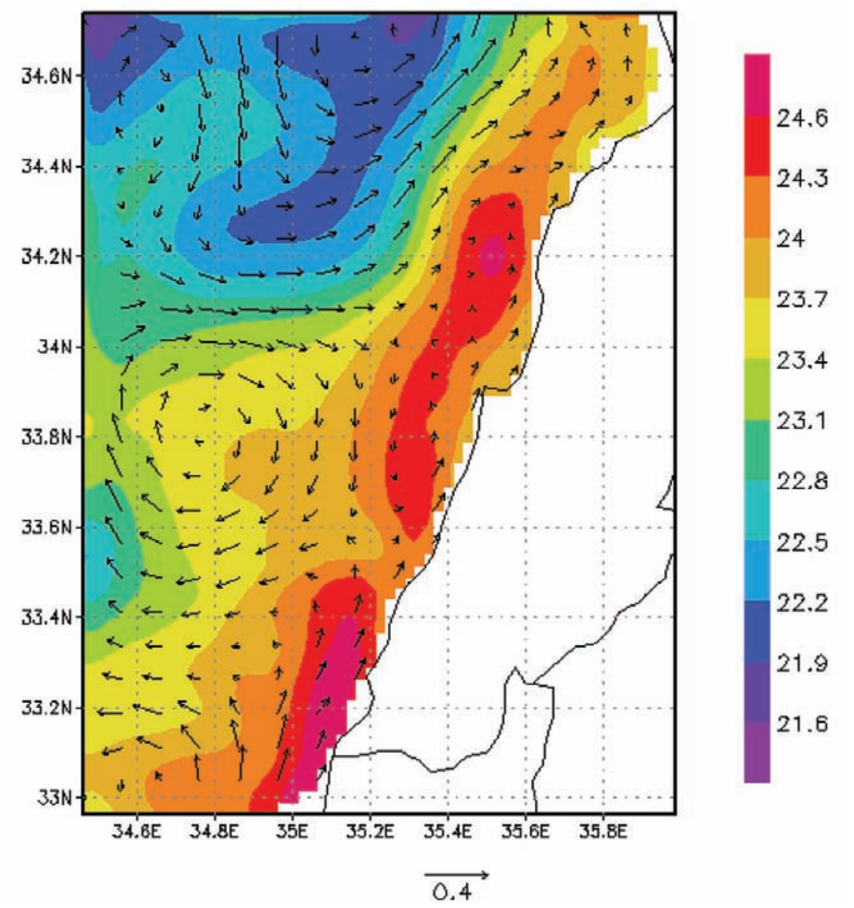
Map 27 - Simulated salinity from LSM at 5m; 10-day average for 10-20 March (from Kabbara et al., 2006)



Map 28 - Simulated salinity from LSM at 5m: 10-day average for 10-20 December (from Kabbara et al., 2006)



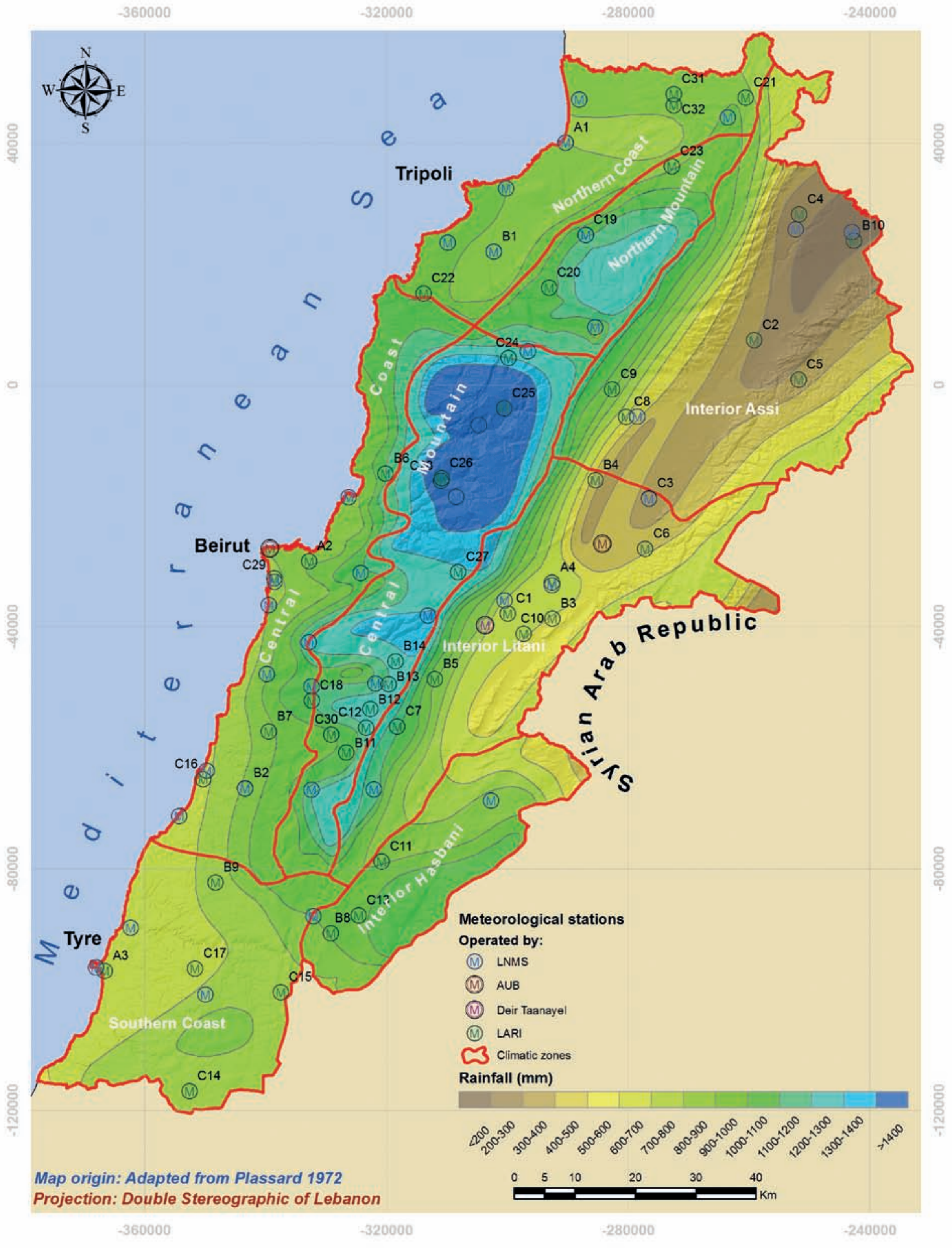
Map 29 - Simulated salinity from LSM at 5m: 10-day average for 10-20 June (from Kabbara et al., 2006)



Map 30 - Simulated salinity from LSM at 5m; 10-day average for 10-20 August (from Kabbara et al., 2006)

Indicators and Aspects of Hydrological Drought in Lebanon
Precipitation:

It is clear that the major precipitation trend is descending and the first decline in precipitation started in the early 1980s. Before that time, the average precipitation rate was 1043 mm, and it decreased to 917 mm (up to 2006), which is equivalent to 12%. Rainfall intensity was also assessed through graphic illustrations of data adopted from TRMM (Tropical Rainfall Mapping Mission). The average number of rainfall peaks was <15 peak/year and 24 peaks/year for the periods before and after the1980s; respectively. Moreover, the average rate of torrential water from these peaks was between 15 and 20 mm/day before the 1980s and 18–22 mm/day after it.



Map 31 - Map for meteorological stations for Lebanon

Rivers

There are 12 permanent watercourses (rivers) in Lebanon. Additionally, there are about 60 major temporary streams (Wadis) that capture rain water for a limited time interval (few months). These watercourses (both permanent and temporary) have witnessed an obvious decrease in water level, and some have lost about 50% of their normal level. The average discharge rate of the Lebanese rivers was 246 million m³/year in the year 1965, this decreased to about 186 million m³/year in the year 2005, which is equal to 23% drop over 40 years.

Springs

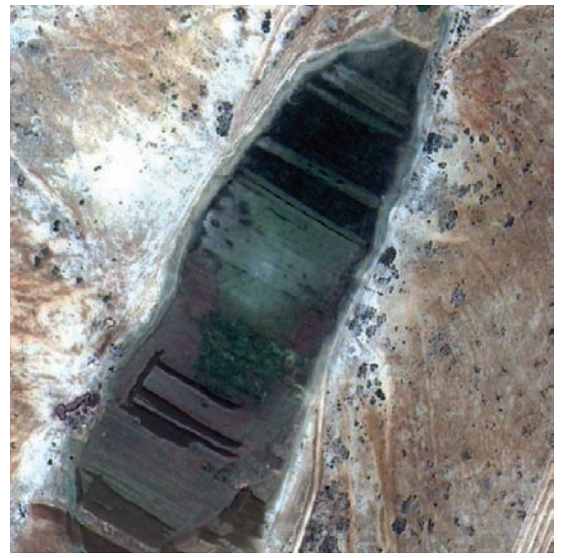
By counting the number of springs from the topographic maps produced in 1963, and in 2005 from field survey data using the same topographic maps, a 50–55% decrease in the number of springs was observed.
The overall trend of discharge from these springs is clearly descending and abruptly changed in the last three decades. The average discharge from these springs was 104 million m³/year, and reduced to 49 million m³/year between 1965 and 1999. This is equivalent to 53% over 34 years.

Map 32 - Lebanon water resources map

Lakes and Reservoirs

In addition, the lake of Qaraoun has witnessed an obvious decrease in its area: the average area was 5.14 km² in the period before 1990 and thus decreased to 4.35 km² after 1990 until 2005, which is equivalent to 15% of the normal area of the lake. Out of 234 known local reservoirs in Lebanon during 1963, only 48 are still in use until 2005. While some other ones remain, but no water storage has been noticed among these reservoirs, except few days after each rainfall period.

Sat. 67 - Ikonos 80 centimetres resolution satellite image for Kawachra lake



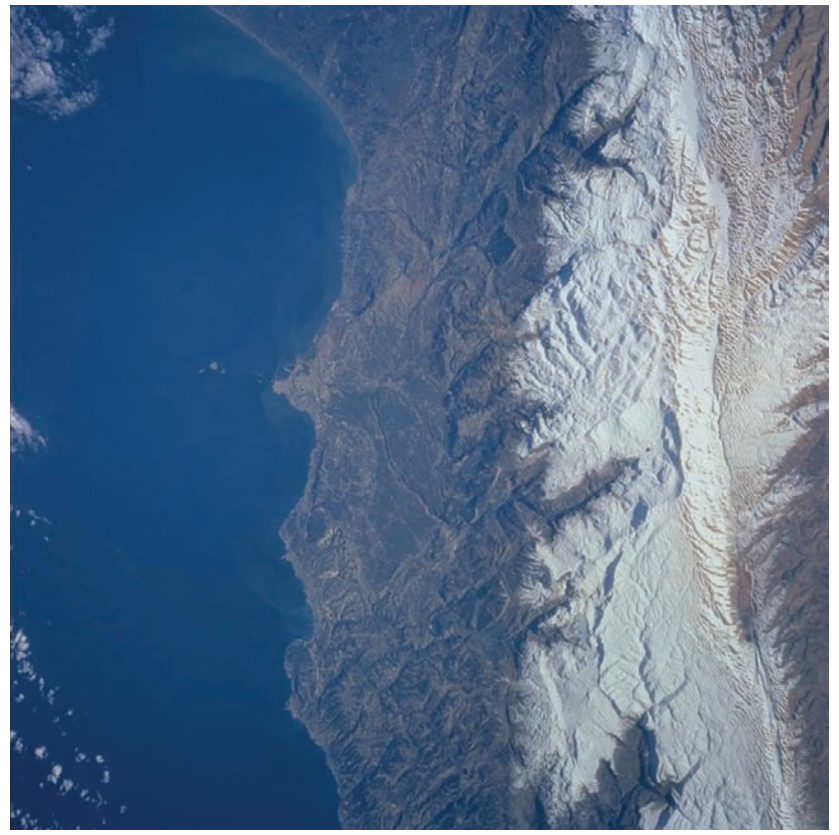
Sat. 68 - Ikonos 80 centimetres resolution satellite image for Marjaheen depression (temporary lake)

Sat. 69 - Ikonos 80 centimetres resolution satellite image for Qaraoun lake

Sat. 70 - Ikonos 80 centimetres resolution satellite image for Bnechaai lake

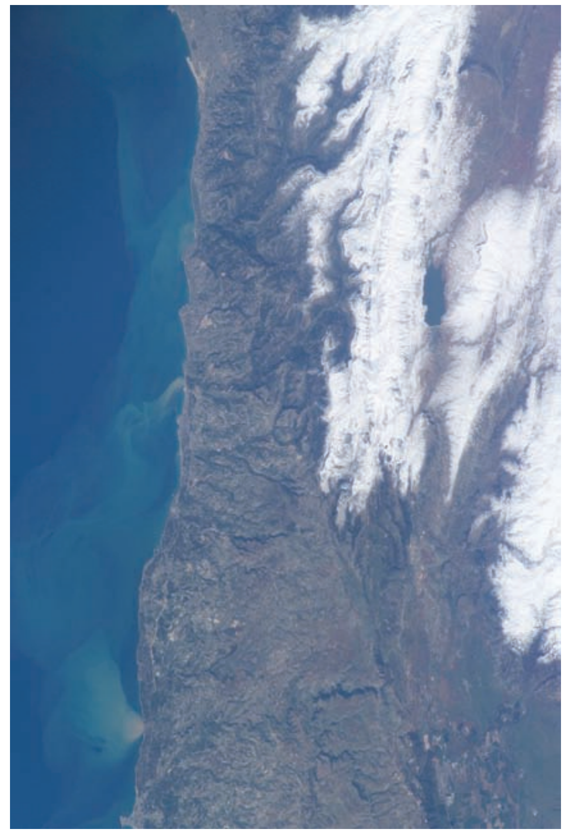
Groundwater:

In the Cenomanian aquifer, 193 water wells were investigated from four different regions to induce the change in water yield between two dates 1984 and 2005. For the Jurassic aquifer, 122 wells were investigated and also in another four regions in Lebanon. For both aquifers, an obvious depletion in the pumped water was recorded, notably in the coastal regions, thus reflecting, in addition to climate influence, the human over exploitation. The average discharge from wells of the Cenomanian aquifer in 1984 in the four studied regions was 29.5 l/s. It decreased to 20 l/s. While in the Jurassic aquifer, the discharge decreased from 31.75 to 23.5 l/s, for 1987 and 2005; respectively. Accordingly, the variation in the level of water table has several values and differs from one area to another. However, the general estimates were adopted as an average from different water wells in Lebanon. For example, the average drawdown in water table was reported as 20–25 and 5–10 m in the Cenomanian and Jurassic aquifer; respectively in the area of the Litani River watershed in the last fifteen years.



Sat. 71 - TERRA, Aster satellite images for Lebanon on January 2nd 2003

Sat. 72 - TERRA, Aster satellite images for Lebanon on February 2nd, 2003



Sat. 73 - TERRA, Aster satellite images for Lebanon on March 3rd, 2003

Snow Cover

Lebanon, the country with about 60–65% of mountainous terrain, receives a considerable amount of snow that covers about 25% of its area. Before 1990s, dense snow often covered more than 2,000 km² of the Lebanese mountains and averaging about 2280 km². Lately, it declined to less than 2,000 km² with an average area of about 1925 km². In addition, the average time in which dense snow remains on mountains before melting also decreased from 110 days to less than 90 days.

Sat. 74 - TERRA, Aster satellite images for Lebanon on December 28th, 2006

Sat. 75 - TERRA, Aster satellite images for Lebanon on December 28th, 2007

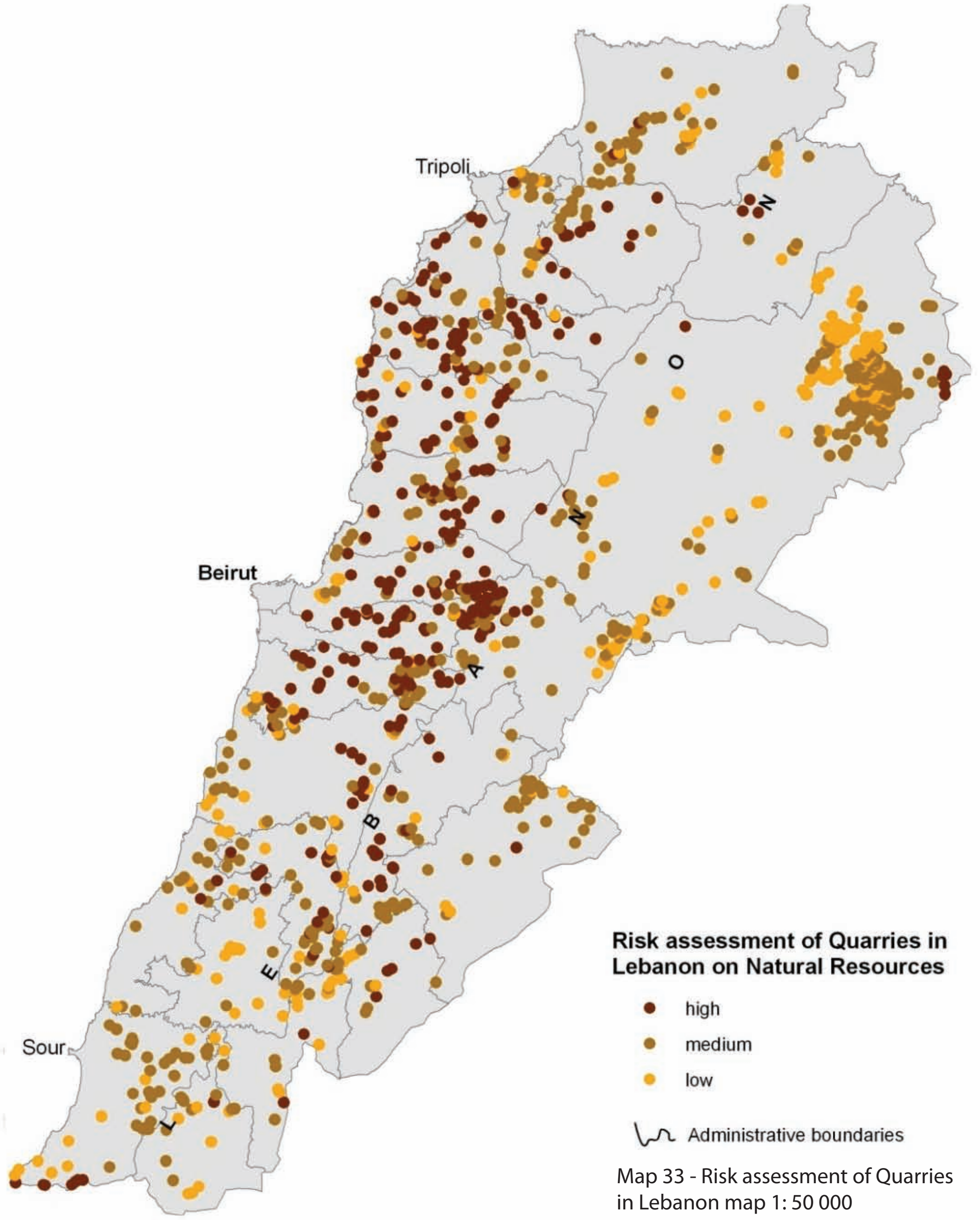
Sat. 76 - TERRA, Aster satellite images for Lebanon on December 28th, 2008

Quarries
Assessment of quarries impact using Remote Sensing techniques

Remote Sensing was used to assess the impact of abandoned and degraded quarries on land resources in Lebanon. Multi temporal analyses of landsat images and Ikonos revealed that between 1996 and 2005 the number of quarries increased from 711 to 1278 and the quarried land area increased from 2875 to 5283 ha.

Quarrying activities affected land cover including forests causing forest fragmentation and land degradation. Unmanaged practices lead to soil erosion and loss of biodiversity in addition to the damage to the air and groundwater quality. Sand excavation in the middle of fruiting pine forest affected the anthropological landscape created by positive human intervention since decades. Gravel extraction left the land with steep slopes negatively affecting the potential spontaneous revegetation.
Modelling the risk of abandoned quarries on land resources in Lebanon using parameters like slope, climate, previous vegetation cover, Land Use and soil types in the surrounding areas, rock infiltration promoting the leaching of pollutants to the groundwater and surface water resources revealed large number of quarries having moderate and high impact.

A total of 105 (8.2%) of detected quarries have a high negative impact on surrounding areas equivalent to a maximum damaged zone of 8247 ha. On the other hand, a total of 842 quarries (65.9%) had moderate effect on 66131 ha of neighbouring lands. From 1278 existing quarries, only 25.9% of them had low negative effect on surrounding natural resources. It is difficult to assess the polluting damage from abandoned quarries during the post exploitation period unless a clear source of pollutant emission is observed in the vicinity. The negative impact was equally observed in the Mount Lebanon and Anti Lebanon mountain range indicating the vulnerability of forest areas and bare lands in term of vegetation risk and water basins. The current practice of quarries management policy in Lebanon needs reconsideration.

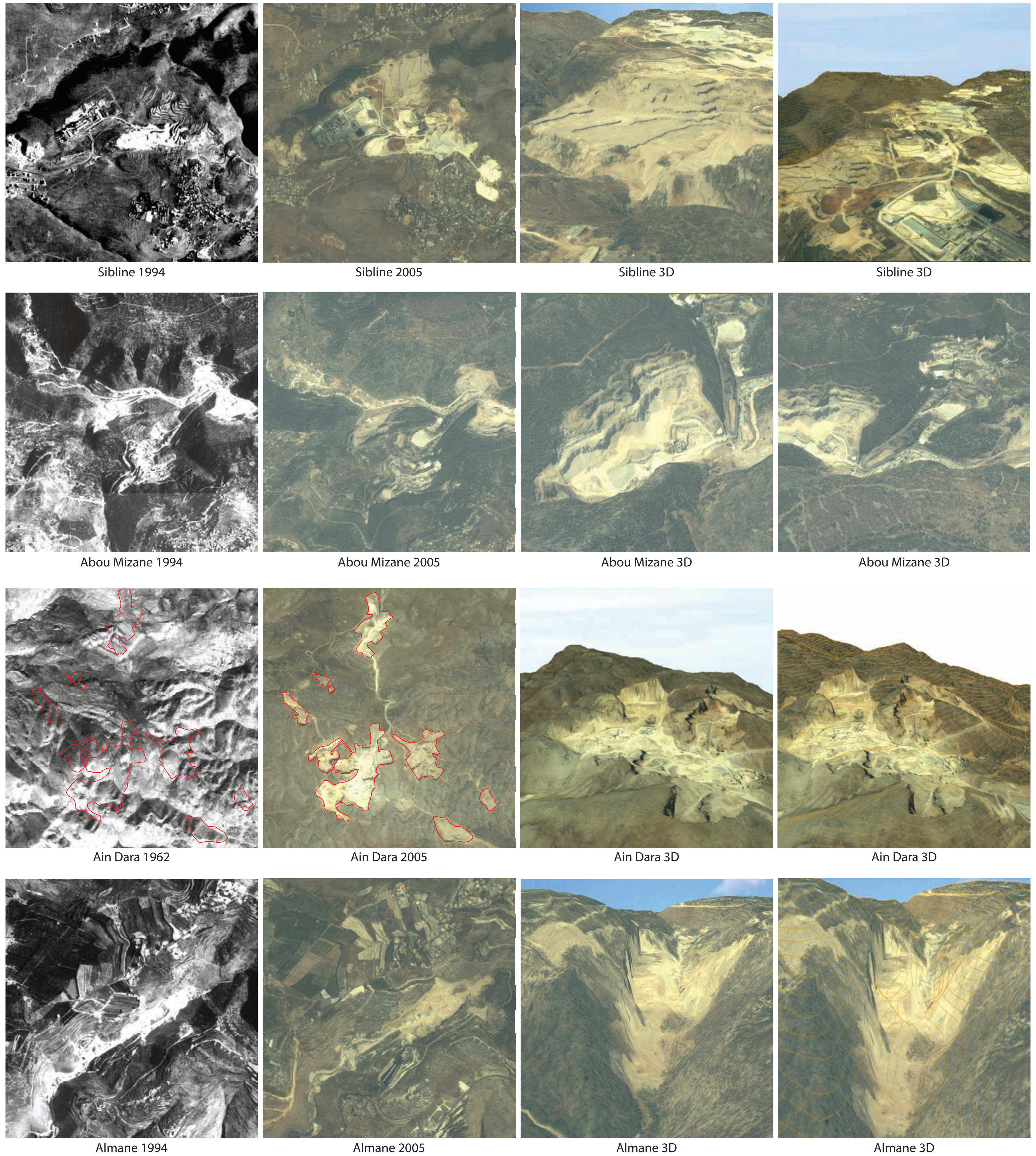


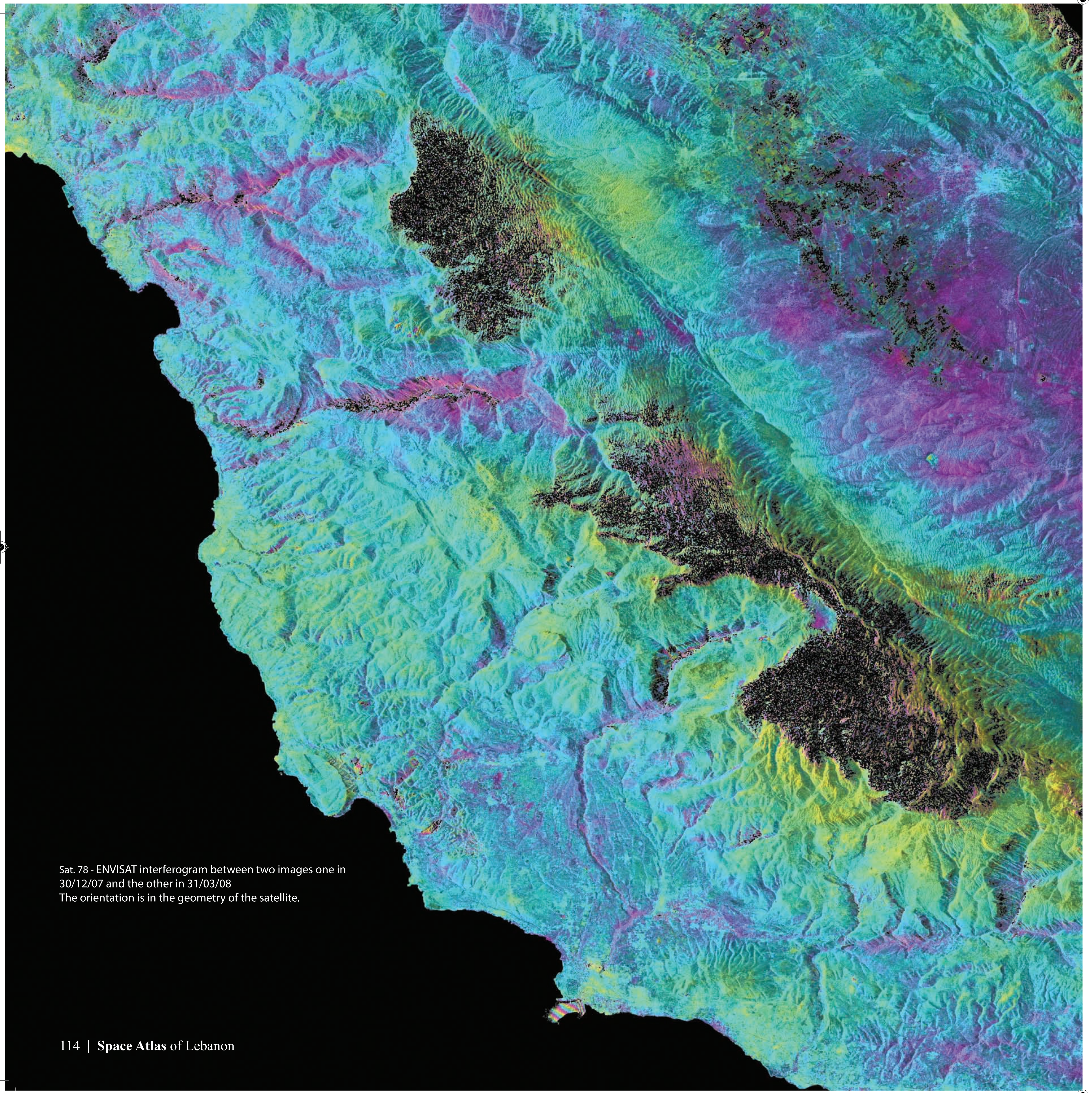
Map 33 - Risk assessment of Quarries in Lebanon map 1: 50 000

Photo 16 - Fruiting pine segmentation by quarries in Safa areag

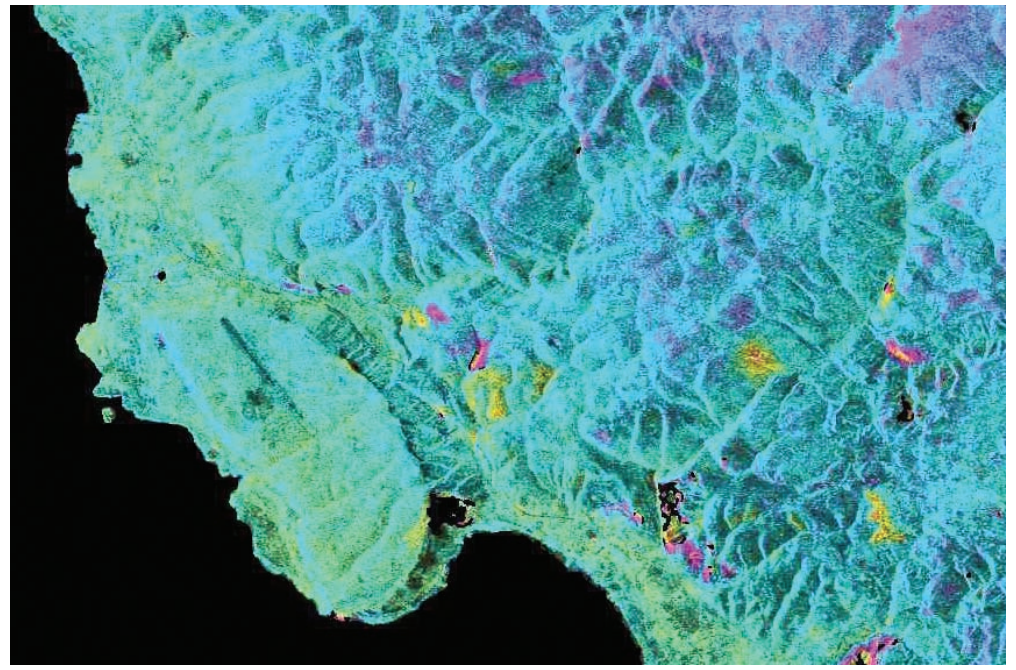
Photo 17 - Limestone quarry in Qartada under oak forest left with vertical walls providing little chance of spontaneous revegetation success.

Sat. 77 - 3D Satellite images for quarries expansion with time: a: Abou-Mizane, b: Ain-Dara, c: Sibline





Sat. 78 - ENVISAT interferogram between two images one in 30/12/07 and the other in 31/03/08
The orientation is in the geometry of the satellite.

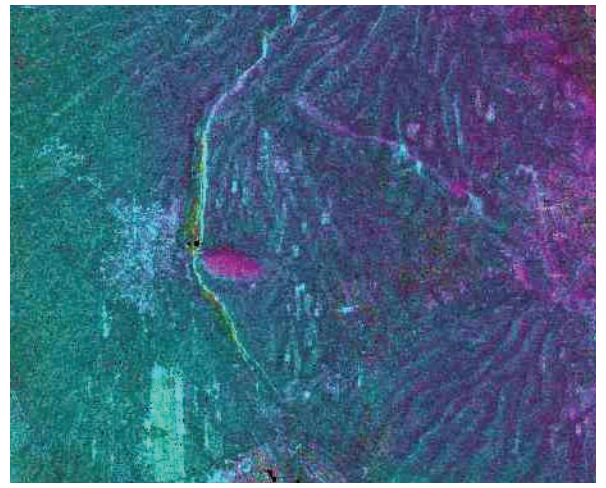


Land slides and bad lands in Saidet Nourieh area –North Lebanon

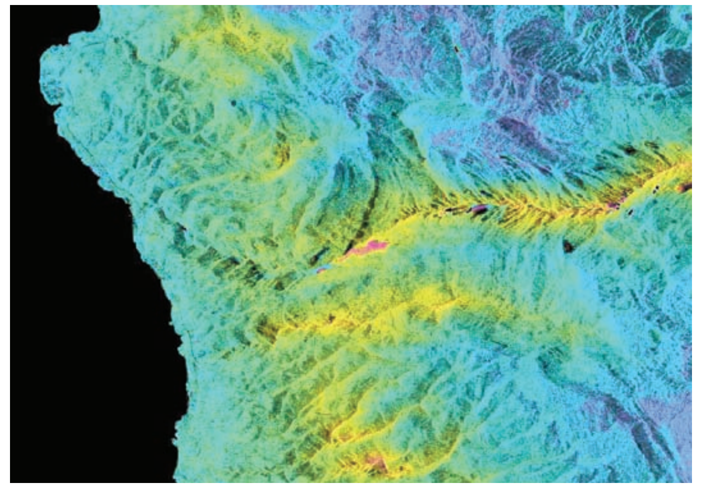
Interferometric Synthetic Aperture Radar. use active sensors emitting a pulse of energy (from a satellite) and recording its return, from the ground, at the sensor. By bouncing signals from a radar satellite off the ground, digital elevation model (DEM) maps can be produced that will show the ground terrain. Two images of the same place are taken at different times then merged, forming a map called an interferogram.

The merging of the two images shows the ground displacement (if any) that would indicate any movement that has occurred between the time the two images were taken. In this way, one can determine if a hillside, for example, has moved.

This displacement is represented into colour fringes Interferogram between two images one in 30/12/07 and the other in 31/03/08



Sat. 79 - ENVISAT Interferogram between two images one in 30/12/07 and the other in 31/03/08
3 months no evidence of creeping Yamouneh _Bekaa



Sat. 80 - ENVISAT Interferogram showing landslides in Naher Ibrahim.
The color fringe is an evidence of a movement

Sat. 81 - ENVISAT Interferogram between two images one in 14/11/07 and the other in 01/07/08
Evidence of creeping in 8 months Yamouneh _Bekaa

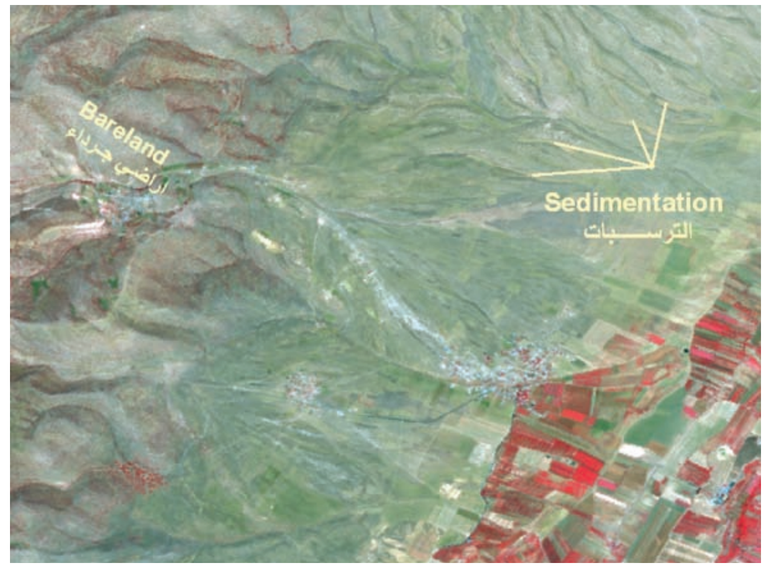
Soil-water erosion, a serious problem in Lebanon

Annual soil loss rates due to water erosion are high reaching about 70 tons/ha in mountainous areas, which constrain seriously any possibility of carrying a healthy vegetal cover. This indicates the extent of the water erosion problem, which threatens an integral element of natural resources in this country, i.e. soil.

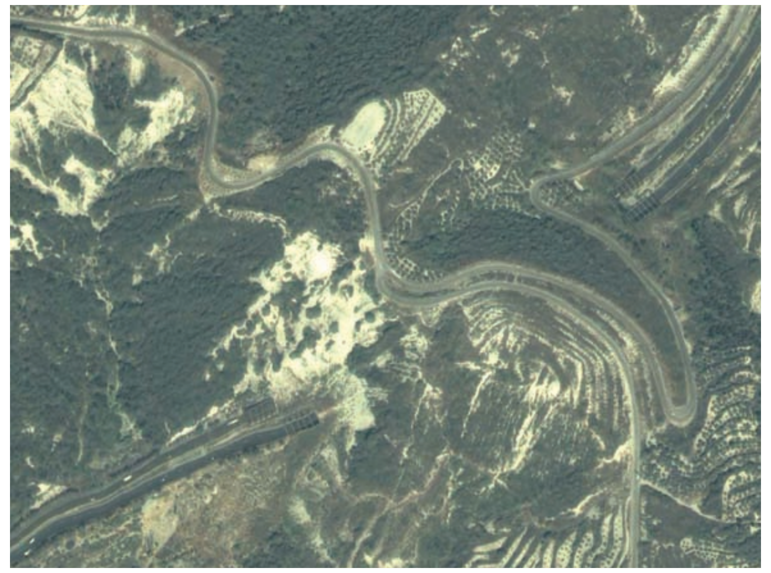
Detection of Soil water erosion by remote sensing

Erosion models are a suitable means for the simulation of present (actual), past, and future erosion states. However, in order to obtain accurate results in a limited period of time for a large area of interest, the acquisition of data for the models is a bottleneck. Field measurements can only take place at certain discrete spots, and have to be extrapolated using grid sampling or geo-statistical methods such as Kriging to generate data artificially for the whole studied area. However, some problems arise with these approaches; they normally require a large number of soil samples, and soil parameter determinations and thus are time consuming. Erosion relevant parameters, i.e. soil type, soil moisture, surface roughness, grain size, organic matter content, soil crust, mineralogical soil constituents, are not suitable for interpolation between point measurements since they are discrete and not continuous variables, and are therefore ideally collected using remote sensing techniques.

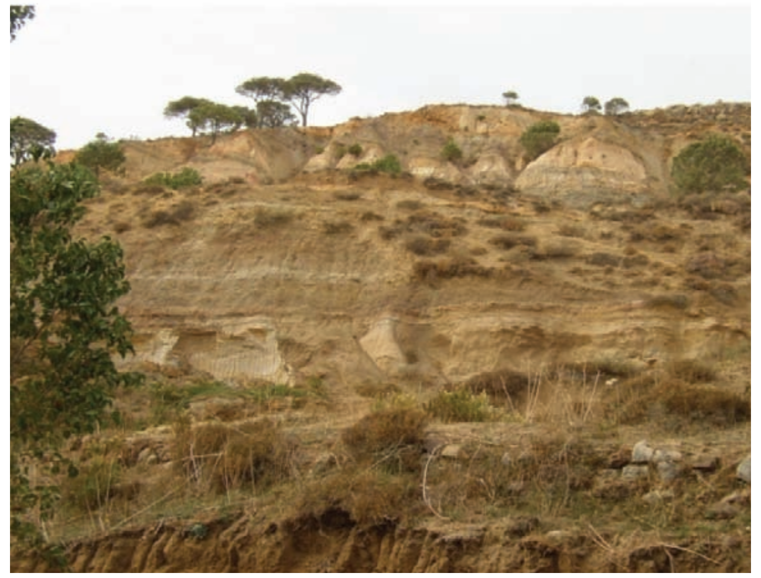
During the last two decades, interaction between electromagnetic radiation (EMR) and soil properties has been derived using optical remote sensing. This interaction seems useful for detecting eroded areas. In the visible portion of the EMR spectrum (RGB tri-chromatic), sheet erosion can be detected through conventional broadband sensors (SPOT, Landsat TM, etc…) via the appearance of humus mollic horizon, usually darker than underlying soil horizons.



Sat. 82 - Ikonos 80 centimeters resolution satellite image for locating the sedimentation due to water erosion



Sat. 83 - Ikonos 80 centimeters resolution satellite image used to depict soil water erosion



Mass erosion sculpturing natural landscapes

Individual gully as the result of linear concentration of intense runoff of surface water

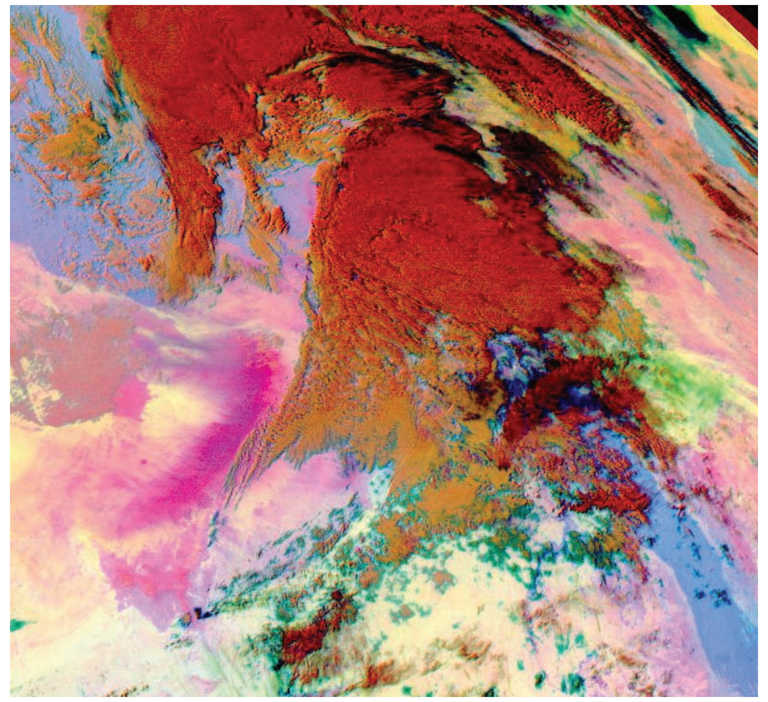
Sheet erosion leading to the removal of the surface horizons in Lebanon

Chaotic quarrying sculpturing the landscapes and increasing the surficial instability processes – Dahr El Beidar

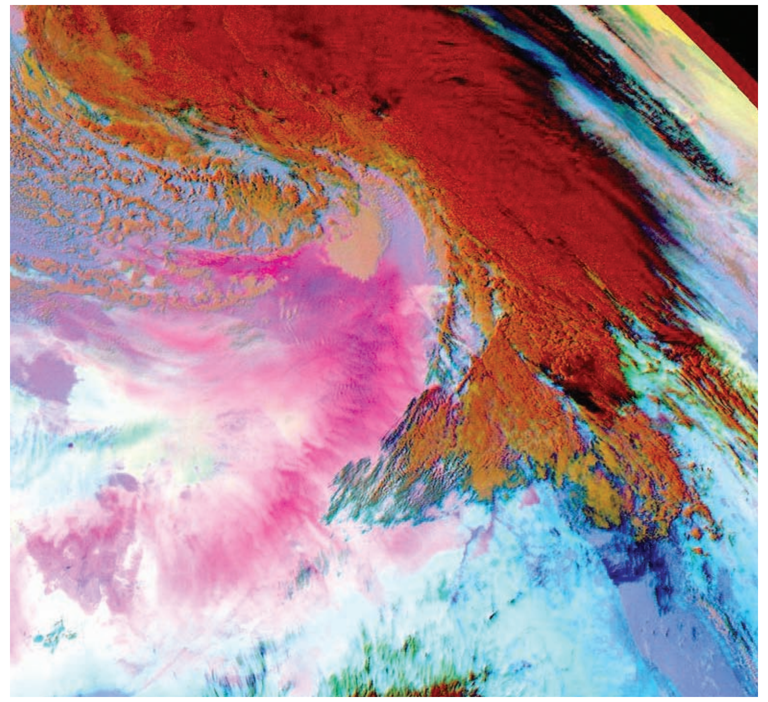
Forest fires influence in triggering soil movements in Ramlieh area (Mount Lebanon)

Dust storm over the Middle East (22-23 January 2004)

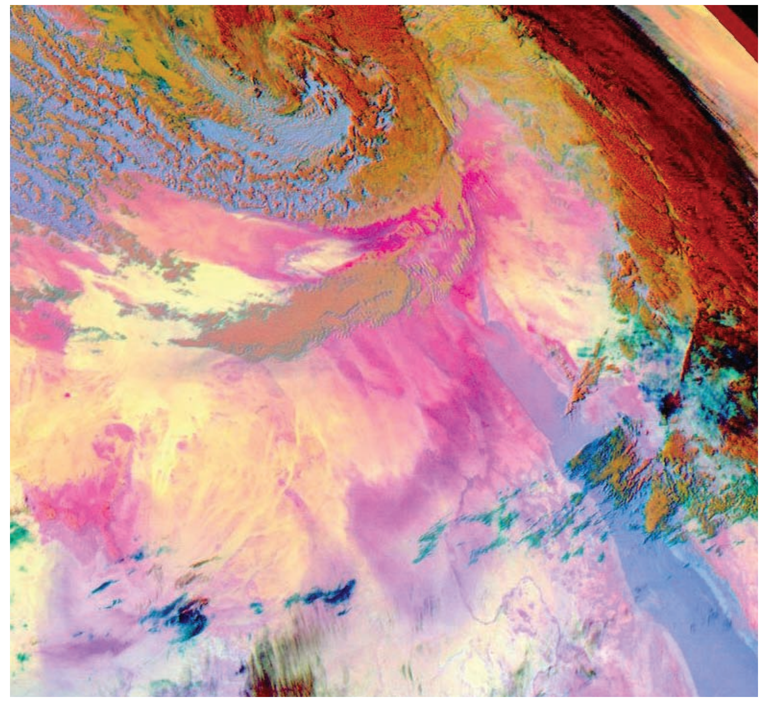
A spectacular case of frontal rain in the Eastern Mediterranean combined with a major dust storm and orographic lee clouds occurred on 21-23 January 2004. The post-frontal dust storm developed over Eastern Libya on 21 January, crossed Egypt on 22 January and moved into the Middle East on 23 January.



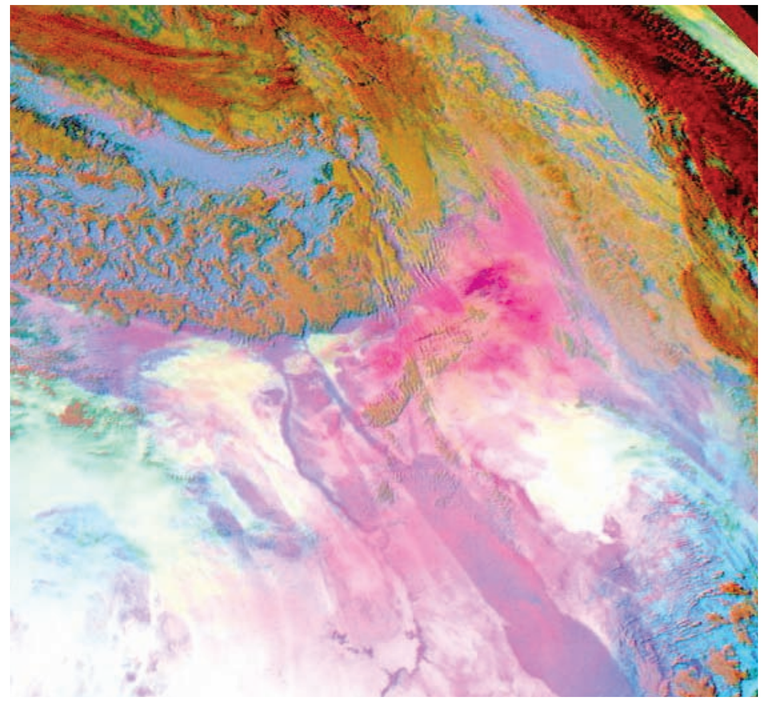
Sat. 84 - TERRA, MODIS image taken on 22 January 2004, 02:00 UTC



Sat. 85 - TERRA, MODIS image taken on 22 January 2004, 12:00 UTC



Sat. 86 - TERRA, MODIS image taken on 22 January 2004, 23:00 UTC



Sat. 87 - TERRA, MODIS image taken on 23 January 2004, 10:00 UTC

Coastal Erosion

The Lebanese coastline shows a linear population growth of 22.13% mainly due to the establishment of several installations during the last forty years. This extension of the artificial shore was done at the expense of natural shores which are becoming increasingly rare. 41% of the littoral is artificialized. This depends mainly on the economic activities related to the sea (fishing ports, trade or recreational facilities, dams, and great urban developments), on the pressure exerted on the littoral (population, land use), and on the type of the coast (weak on the coasts with cliffs, more important on the sandy coasts).

The shore is currently affected by an important erosion of 45.24%. One of the reasons is that Lebanese coast endures massive winter storms and high speed currents in a North North-Eastern direction. These two factors constitute risks for sandy beaches. The velocity of the currents necessitated the establishment of large blocks used to protect the beach from natural erosion.

These risks were aggravated by the sand extraction from the beaches during the war and undoubtedly by the reduction of the sediments contributions since the construction of the barrier of Aswan. The recent embankments (ports, the international airport of Beirut and the urban installations and equipment) and certain sand pumping from nearby sea-beds are also factors affecting the littoral hydrodynamics.

Aerial 17 - Aerial photo for the Bourj Hammoud Dump site in (a) 1956, (b) 1971 and (c) 1994

Sat. 88 - Ikonos 80 centimeters resolution satellite image for the Lebanese shore

Source of Data

- **Satellite Images**
  - National Council for Scientific Research
  - Directorate of Geographic Affairs (D.A.G)

- **Aerial photos**
  - Directorate of Geographic Affairs (D.A.G)

- **Maps**
  - Ministry of environment
  - General Directorate of antiquities
  - National Council for Scientific Research

- **Statistical information**
  - Central Administration for Statistics
  - Council for Development and Reconstruction

Characteristics of satellite data				
Satellite name	**Type of images**	**Resolution**	**Year**	**Company**
ENVISAT ASAR	Radar	20 m	2007 - 2008	European Space Agency
Ikonos	Multispectral	80cm	2005	Digital Globe
Russian satellite KVR 1000	Photography	2 m	1994	GIS/Transport
Landsat 7 ETM + (Enhanced Thematic Mapper Plus)	Multispectral	30m	2005	USGS
TERRA, MODIS	Multispectral	250m	2004	NASA
TERRA, Aster	Multispectral	30m	2003	NASA

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